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A case report of Sotos syndrome treated with nonsurgical orthodontic technique

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Highlights

- Sotos syndrome is categorized as overgrowth syndromes presenting prenatally.
- This is the first case report in which the long-term follow-up of a patient with Sotos syndrome was performed.
- A case of skeletal Class III involved in Sotos syndrome was treated with nonsurgical orthodontic technique.
- Much attention should be paid to the early orthopedic treatment with the facemask and/or chin cap for Sotos syndrome.

A case report of Sotos syndrome treated with nonsurgical orthodontic technique

Abstract

Sotos syndrome is a genetic disorder characterized by overgrowth in childhood, specific facial manifestations, advanced bone age, and mental retardation. Although only one case report of Sotos syndrome treated with surgical orthodontics has thus far been published, there have also been a few detailed reports of long-term observation of Sotos syndrome through total orthodontic treatment. This article aimed to present the case of a growing patient with skeletal mandibular protrusion and unilateral posterior crossbite as present in Sotos syndrome treated with a non-surgical orthodontic technique. A 10-year-old boy was diagnosed with skeletal mandibular protrusion and posterior crossbite associated with Sotos syndrome. After maxillary lateral expansion, the skeletal Class III relationship with an anterior crossbite improved owing to mandibular clockwise rotation, while the facemask had a marginal effect. At the completion of growth at 16 years, he had a skeletal Class I relationship, and thus, conventional orthodontic treatment with preadjusted edgewise appliances was initiated. After 41 months of multibracket treatment, acceptable occlusion with a functional Class I relationship was obtained. At 12 months postretention, no or few changes in occlusion and facial features were observed. Our results demonstrate that considering the maxillofacial vertical growth during peripubertal period associated with Sotos syndrome, much attention should be paid to the early orthopedic treatment with the facemask and/or chin cap.

Key words: Sotos syndrome; long-term management; overgrowth; skeletal Class III

INTRODUCTION

Overgrowth is commonly divided into three phenotypes: prenatal, post-natal and segmental overgrowth.[1] Of the three phenotypes, Sotos syndrome is categorized as a prenatal overgrowth syndrome, along with Beckwith-Wiedemann syndrome and Weaver syndrome.[2] Patients with Sotos syndrome exhibit increased height, especially for the first 4 years of life, macrosomia, dolichocephaly and macrocephaly, while they also show learning and intellectual disabilities, indicative of mental retardation.[3-7]

Regarding the characteristic maxillofacial features, tapered mandible and small maxillary dental arch have previously been reported.[2,8] Cole and Hughes[4] demonstrated that 54% of patients with Sotos syndrome exhibited early eruption of deciduous teeth, and Kotilainen et al[4] reported congenitally missing premolars in 69% of cases. Furthermore, other features frequently seen in Sotos syndrome are maxillary and mandibular recession, a long mandible with pointed chin, posterior crossbite and a narrow dental arch with proclined maxillary incisors,[7] while mandibular prognathism is rare.[6,9] Considering this, a characteristic occlusion for Sotos syndrome could not identified due to large interindividual variability in skeletal abnormalities.[4]

To the best of our knowledge, one patient with Sotos syndrome was orthodontically treated with distraction osteogenesis.[8] Although previous studies have reported craniofacial growth patterns during the prepubertal period in patients with Sotos syndrome,[6,10] there have been relatively few detailed reports of long-term observation through total orthodontic treatment. Therefore, little information is available on the efficacy of conventional orthodontic treatment, including early orthopedic treatment, in patients with Sotos syndrome.

The purpose of this report was to present a growing patient with skeletal mandibular protrusion and posterior crossbite as presented in Sotos syndrome, treated with a nonsurgical orthodontic technique.

DIAGNOSIS AND ETIOLOGY

A boy, aged 10 years, was referred to the Department of Pediatrics, ****** University Hospital with a chief complaint of anterior crossbite and salivation. At the age of 4 years and 6 months, he was diagnosed with Sotos syndrome. At birth, his body height, weight and head circumference was within the normal range; however, at the age of 10 months, his height had reached 78.6 cm, 2 standard deviations (SD) taller than Japanese male standards.[11] At the age of 5 years and 9 months, his body height and head circumference were 123.7 cm and 56.0 cm, respectively, both of which were > 2 SD greater than the standards for Japanese males.[11,12] The patient's mental development was also evaluated using the Wechsler intelligence scale for children-third edition (WISC-III).[13] His verbal intelligent quotient (IQ), performance IQ and full scale IQ were 67, 71 and 65, respectively, and he was thus diagnosed with mental retardation. A radiograph of the hand and wrist taken at age 6 years and 1 month, showed that his right third, fourth, and fifth metacarpal bones were completely fused. According to the Tanner-Whitehouse 2 (TW2) using radius-ulna-short bones (RUS) scoring system, his bone age was evaluated as 11 years and 4 months for the right hand and 10 years and 1 month for the left hand, indicating advanced bone maturation.[14,15]

At the first examination (aged 10 years), facial photographs showed asymmetry, with a deviated chin on the left side, large lower facial height, and epicanthus (Fig 1). His chin presented with a mentalis strain during lip closure. The lateral profile was straight. Intraoral photographs showed that the mandibular dental midline deviated 3 mm to the left in relation to his facial midline. An anterior crossbite of -1.7 mm was observed, and the molar relationship was Angle Class III on both sides (Fig 2). Furthermore, a posterior crossbite was present at the left molar site. He had habits of mouth breathing and tongue thrusting when chewing and swallowing. His bone age was defined as 13 years and 5 months after evaluation by the TW2-RUS method (Fig 3),[14,15] while according to the cervical vertebral maturation (CVM) method, he was classified as CVM stage 3, and his bone age was calculated as 13 years and 8 months.[16,17] His body height was 152.0 cm, which was +2.6 SD taller than Japanese male standards (Fig 4).[11,12]

A panoramic radiograph showed no congenitally missing permanent teeth (Fig 5). Cephalometric analysis, when compared to the Japanese male standards,[18] exhibited a skeletal Class III relationship (ANB, 0º). Although the SNB angle was within the normal range, considering that the anteroposterior length of the anterior cranial base (SN) was +3 SD larger, and the mandibular ramus height (Ar-Go), body length (Go-Me) and total length (Ar-Me) were more than +2 SD larger than those of the Japanese male standards, he was classified as having a skeletal mandibular protrusion (Fig 5; Table I). His anteroinferior facial height was larger than +2 SD of the Japanese norm (Me/palatal plane, 72.6 mm). The gonial angle was greater than the norm, while the mandibular plane angle was within the normal range (gonial angle, 134.3º; FMA, 31.5º). The maxillary central incisors were proclined (U1-SN, 110.2º). The inclination of the mandibular central incisors was within the normal range (IMPA, 87.3º). The Wits appraisal, the perpendicular distance between the points A and B on the occlusal plane, was -3.5 mm. Posteroanterior cephalometric analysis[19] showed 3.4 mm of dental midline leftward deviation, 5.2º of maxillomandibular midline leftward deviation, and -1.8 mm of maxillary occlusal plane tilt (Fig 5; Table II).

TREATMENT OBJECTIVES

The treatment objectives were (1) to improve his anterior crossbite and unilateral posterior crossbite, (2) to promote maxillary forward growth and restrict mandibular forward growth, and (3) to obtain an acceptable Class I occlusion with a functional interincisal relationship. The treatment planning was: (1) maxillary lateral expansion using a hyrax appliance to improve unilateral posterior crossbite, (2) use of facemask to observe maxillary protraction and improve anterior crossbite, (3) multibracket treatment for tooth alignment, and (4) surgery after growth, if necessary. Oral myofunctional therapy (MFT) was also admistrated to remove his parafunctional habit.

TREATMENT ALTERNATIVES

As patients with Sotos syndrome often show a deficient maxilla with a narrow maxillary arch and tapered mandible, orthognathic surgery may be necessary. Takano et al[8] previously reported a case of Sotos syndrome treated with surgically facilitated maxillary expansion and mandibular distraction osteogenesis, and demonstrated that surgically assisted orthodontics after complete growth is one of the treatment remedies to improve occlusion in patients with Sotos syndrome. Meanwhile, no information is available regarding the prognosis of early orthopedic treatment aimed at promoting maxillary forward growth and to restraining mandibular forward growth. Therefore, in the present case, surgical modalities were proposed as a treatment plan if the horizontal skeletal discrepancies worsened after physical growth was complete. Since the use of facemask result in not only maxillary forward growth and mandibular forward growth restriction but also mandibular clockwise rotation, these treatment therapies might not be suitable for patients with skeletal open bite with increased lower anterior facial height. However, our patient showed an average mandibular plane angle with a large mandible, therefore, we decided to use aforementioned equipment to treat the mandibular protrusion by mandibular forward growth restriction and clockwise mandibular rotation.

TREATMENT PROGRESS

When the patient was 10 years and 3 months old, he was fitted with a hyrax appliance, and the maxilla was expanded at a rate of 0.5 mm/day. The total amount of maxillary expansion between maxillary first molars was 5.0 mm, resulting in improvement of the unilateral posterior crossbite. Immediately after maxillary palatal expansion, a maxillary protraction was observed using a facemask. The patient was instructed to use the appliance for at least 10 hours/day to correct the anterior crossbite; however, due to his mental retardation, he could not understand the implication of orthodontic treatment. Since his mother was cooperative to orthodontic treatment for him, he could wear the facemask every day and the compliance reached at least 10 hours/day use. By using the facemask with a total of 600-g protraction forces for 9 months, his anterior crossbite improved, and the overjet was increased to 7.0 mm. Cephalometric analysis after initial treatment revealed that the ANB angle increased with mandibular clockwise rotation, although maxillary forward growth was not significantly promoted by the facemask (Fig 6; Table I). His bone age was defined as 14 years and 4 months according to the TW2-RUS method and 14 years and 6 months according to the CVM method (Figs 3 and 6).[14-17] His body height was 158 cm, which was > 2 SD taller than the Japanese male standards (Fig 4).[11] Thereafter, only chin cap therapy was performed until his growth completed in order to prevent mandibular overgrowth[20,21] to the greatest extent possible (Fig 6; Table I). During the 3-year treatment with a chin cap, maxillary forward growth was observed, and the ANB angle was increased to 4.3°, indicating a skeletal Class I relationship. The value of Wits appraisal increased by 7.5 mm and became +4.0 mm. The mandibular plane angle (FMA) was increased to 35.7º, indicating a high mandibular plane angle. Throughout the 1st phase of the treatment, the patient continued to follow instructions as per the MFT to correct his myofunctional problems, which included tongue thrusting and mouth breathing; however, these problems could not be overcome. At the age of 14 years, his bone age evaluated by TW2-RUS method was defined as 15 years and 10 months (Fig 3), implying that his bone had already matured.[14,15] According to the CVM method, he was classified as CVM stage 5, and his bone age was calculated at 16 years and 5 months old.[16] His body height was 176 cm, which was +1.8 SD taller than the Japanese male standards (Fig 4).[11]

At the age of 16 years, all permanent teeth had erupted, and physical growth was almost complete. At this time, his body height was 179 cm, which was +1.7 SD taller than the Japanese male standards (Fig 4). His lateral profile changed to a convex type with upper and lower lip protrusions (Fig 7). He exhibited moderate crowding of both the upper and lower anterior dentitions, a 3.9 mm of overjet, and a 0.5 mm overbite (Fig 8). The canine and molar relationships were Class I on both sides. Arch length discrepancies were -3.5 mm and -5.5 mm for the maxillary and mandibular arches, respectively. A panoramic radiograph revealed the existence of bilateral upper and lower third molars and no abnormality or deformation of either condyle (Fig 9). Cephalometric analysis revealed a skeletal Class I (ANB, 3.8º) and a high mandibular plane angle (FMA, 37.3º) (Fig 10; Table I). The maxillary central incisors were still proclined (U1-SN, 111.8º), while the mandibular central incisors were slightly inclined lingually (FMIA, 52.4º; IMPA, 90.3º). From 14 to 16 years of age, mandibular downward growth was still continuing, while mandibular forward growth had almost stopped and the value of Wits appraisal maintained +4.0 mm (Fig 10). Posteroanterior cephalogram[19] showed a 3.4 mm leftward deviation of the mandibular dental midline and a 4.0º maxillomandibular midline leftward deviation (Fig 9; Table II). The occlusal plane tilt was decreased to -1.1 mm. According to the CVM method,[16,17] he was classified as CVM stage 6 and his bone age was calculated as 18 years old, while his body height was 179 cm, +1.6 SD taller than the Japanese male standards (Fig 4).[11]

After extraction of all third molars, the patient, aged 16 years and 1 month, started to receive multibracket treatment as the 2nd phase. Preadjusted edgewise appliances with a 0.018-in slot were set on the maxillary and mandibular teeth to correct anterior crowding. After leveling with nickel-titanium alloy wires, orthodontic miniscrews were inserted bilaterally between the maxillary and mandibular second premolars and first molars. To distalize all teeth, a 200-g force was applied with elastic chains anchored between the canine and orthodontic miniscrew on each side. After 3 years and 5 months of active treatment (aged 19 years and 6 months), an acceptable occlusion with close intercuspation was achieved, and all the appliances were removed. Wraparound type retainers were placed on both the upper and lower teeth and used for the whole day except eating and tooth-brushing. A lingually bonded retainer was also placed on the mandibular anterior teeth.

TREATMENT RESULTS

Posttreatment facial photographs showed an improvement in lip protrusion although the lateral profile was still convex (Fig 11), while the mentalis strain at the lip closure was reduced. Close intercuspation of the teeth was performed with functional canine guidance during lateral mandibular movement. Overjet and overbite were improved to 1.3 mm and 1.1 mm, respectively, and a proper interincisal relationship was achieved (Fig 12). Canine and molar relationships were maintained in a Class I relationship. A panoramic radiograph revealed root parallelism (Fig 13). Posttreatment cephalometric analysis indicated a skeletal Class I relationship (ANB, 3.6º) (Fig 14; Table I). The mandibular plane angle was still higher than the Japanese male standard (FMA, 36.4º) but no impairment (clockwise rotation of the mandible) was present during multibracket treatment (Fig 14; Table I). The inclination of the maxillary central incisors was improved (U1-SN, 102.8º) and the mandibular central incisors showed less changes in its inclination (FMIA, 53.7º; IMPA, 89.9º). The value of Wits appraisal was decreased to +3.5 mm. A posteroanterior cephalogram[19] revealed matching of the maxillary and mandibular dental midlines, whereas the maxillomandibular midline was still deviated by 3.5º to the left (Fig 14; Table II). The occlusal plane tilt was decreased to -0.4 mm. According to the CVM method,[16,17] his bone age was calculated as 19 years as the CVM stage 6.

At 12 months postretention (aged 20 years and 6 months), the lateral profile showed no or few changes. The occlusion was well maintained without any relapse of anterior crowding (Figs 15 and 16). A proper interincisal relationship was maintained under functional guidance. A panoramic radiograph showed little or minimal changes in the alveolar bone level and root parallelism (Fig 17). Cephalometric evaluation revealed little or no changes, without any substantial relapse in the skeletal and dental aspects (Fig 14; Table 1). Posteroanterior cephalometric analysis showed no changes during the 12 months retention period (Fig 17; Table II).

DISCUSSION

Patients with craniosynostosis conditions, such as Apert and Crouzon syndrome also exhibit skeletal mandibular protrusion due to severe maxillary growth deficiency.[22] Previous literature has indicated that the solution to such marked skeletal problems involving genetic diseases were limited by the insufficiency of the recovery of maxillary horizontal growth by early orthopedic treatment.[23] Meanwhile, Sotos syndrome is a rare genetic disease, and little information is available on the effectiveness of early orthopedic treatment on patients with Sotos syndrome. The present patient exhibited slight maxillary forward growth during treatment with a facemask; however, the maxillary growth rate was almost similar to that in normal males. This implies no or less acceleration of maxillary forward growth induced by early orthopedic treatment with the facemask.

It is known that a long-term treatment with chin cap therapy resulted in a significant backward rotation of the mandible, indicating an increase of the mandibular plane angle.[21,24] Abdelnaby and Nassar[25] also demonstrated that the use of a chin cap improved the maxillomandibular base relationship in growing patients with Class III malocclusion due to a decrease of the ramus height and an increase of the mandibular plane angle but with only minor skeletal effects. Takei et al.[6] evaluated the changes in maxillofacial growth in two patients with Sotos syndrome, and demonstrated that both patients exhibited an increase in the mandibular plane angle during the peripubertal period without any orthodontic treatment. Our patient also exhibited mandibular vertical growth during observation period after phase I treatment (Figure 10). These imply that the maxillofacial vertical growth is considered important in the treatment of this syndrome. Although the present patient with Sotos syndrome had an average mandibular plane angle at the initial stage and improved the anterior crossbite by the unexpected excessive mandibular clockwise rotation, we maybe should not use a facemask and chin cap taking into account prevention of mandibular vertical overgrowth, in our case.

Sotos syndrome is likely to advanced bone age with early bone maturation.[26,27] According to the TW2-RUS method,[14,15] our patient also showed early bone maturation, and his bone age was evaluated as 13.4 years, 14.3 years and 15.8 years at the age of 10, 11 and 14, respectively. His bone maturation level at 14 years was almost that of an adult. Conversely, according to the CVM method,[16,17] his bone age was assessed as 13.7 years, 14.8 years, 16.4 years and 18.0 years at the age of 10, 11, 14 and 16, respectively. Regarding the CVM stage, his cervical vertebra at the age of 14 had already matured, and was classified as CVM stage 5. This indicates that the bone age evaluated by the TW2-RUS method was almost matched to that evaluated by the CVM method in patients with Sotos syndrome as well as the general populations.[28] The CVM method for the assessment of skeletal age has proven to be highly reliable and can be performed on a cephalometric radiograph, resulting in the elimination of the additional hand-wrist radiograph.[28,29]

Before orthodontic treatment, we measured the lip-closing force using a simple measurement device (Lipplekun, Shofu Co., Kyoto, Japan), and found that the patient had a lip-closing force of only 8.9 N, which was significantly lower than the Japanese 15-year-old male standard (13.4 N ± 2.9 N). It is known that the force of the lip closure in children with mouth breathing is significantly smaller than that in children with nasal breathing.[30] In addition, it is suggested that MFT including lip muscle training upregulates the maximum lip closing force and improves mouth breathing.[31] In particular, several researchers have demonstrated that the combination of MFT and orthodontic treatment was more successful in correcting lip incompetence than MFT alone.[32,33] Furthermore, throughout the 1st phase treatment, we provided the patient with MFT to correct myofunctional problems including tongue thrusting during chewing and swallowing. Eventually, although the lip closing force was increased to 11.5 N, he could not overcome myofunctional problems and he retained the habits of tongue thrusting and mouth breathing after treatment. Owing to the mental retardation, we could not obtain the patient’s cooperation in other treatment processes. Regarding mental retardation, 80%-100% of patients with Sotos syndrome have developmental delays, and the degree of intellectual impairment varies greatly among them.[34] In our patient, the mental development level evaluated using the WISC-III was slightly lower than the normal level, indicating a mild delay in mental development. It is difficult to end a series of orthodontic treatments and achieve sufficient treatment outcomes without patient cooperation. This may explain why only a limited number of case reports of orthodontically treated patients with Sotos syndrome have been published. Furthermore, since residual parafunctional habits are subject to severe relapses, such as open bite, our results indicate the necessity for long-term observation of a patient with Sotos syndrome after active orthodontic treatment.

CONCLUSION

Although early orthopedic treatment with the facemask and chin cap was not effective, his anterior crossbite improved by mandibular clockwise rotation, and an acceptable occlusion was well retained throughout the 1-year retention period. Considering the maxillofacial vertical growth during peripubertal period associated with Sotos syndrome, much attention should be paid to the early orthopedic treatment with the facemask and/or chin cap.

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Figure legends

Figure 1. Pretreatment facial and intraoral photographs at the age of 10 years.

Figure 2. Pretreatment dental casts.

Figure 3. Images of hand-wrist radiographs at different ages: A, 10 years old; B, 11 years old; C, 14 years old.

Figure 4. Patient growth chart plotted on the Japanese male growth chart depicting actual height and yearly height increments. Red plots indicate actual patient height. Blue plots indicate yearly height increment of the patient. Bold lines represent the average growth curve and average yearly height increment of a Japanese male. Black dotted lines indicate +2.0 SD, +1.0 SD, -1.0 SD, and -2.0 SD.

Figure 5. Pretreatment panoramic radiograph, lateral and posteroanterior cephalograms, and their tracings.

Figure 6. Cephalometric tracings before treatment (black; age 10 years), after initial treatment with maxillary lateral expansion and maxillary protraction (blue; age 11 years), and after orthopedic treatment with chin cap (red; age 14 years) superimposed on the inner contour of the anterior wall of sella turcica, the anterior contour of zygomatic process, and the inner contour of cortical plate at the lower border of the symphysis.

Figure 7. Facial and intraoral photographs before 2nd phase treatment at the age of 16 years.

Figure 8. Dental casts before 2nd phase treatment.

Figure 9. Panoramic radiograph, lateral and posteroanterior cephalograms, and their tracings before 2nd phase treatment.

Figure 10. Cephalometric tracings after 1st phase treatment (black; age 14 years) and before 2nd phase treatment (red; age 16 years) superimposed on the inner contour of the anterior wall of sella turcica, the anterior contour of zygomatic process, and the inner contour of cortical plate at the lower border of the symphysis.

Figure 11. Posttreatment facial and intraoral photographs at the age of 19 years and 6 months.

Figure 12. Posttreatment dental casts.

Figure 13. Posttreatment panoramic radiograph, lateral and posteroanterior cephalograms, and their tracings after 2nd phase treatment.

Figure 14. Cephalometric tracings before 2nd phase treatment (black; age 16 years), posttreatment (red; age 19 years and 6 months), and after 1-year retention (green; age 20 years and 6 months) superimposed on the inner contour of the anterior wall of sella turcica, the anterior contour of zygomatic process, and the inner contour of cortical plate at the lower border of the symphysis.

Figure 15. Facial and intraoral photographs after 1-year retention at the age of 20 years and 6 months.

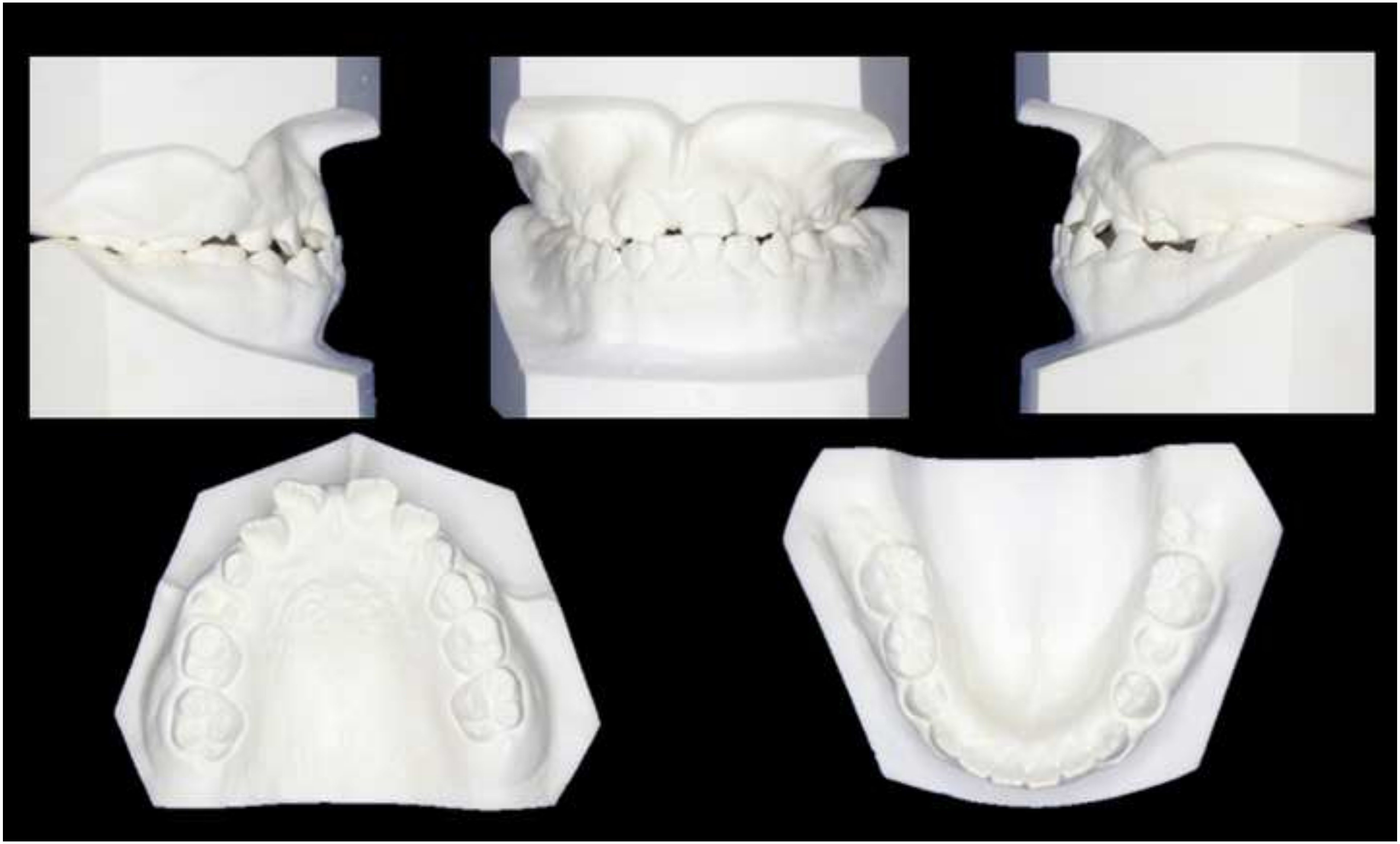
Figure 16. Dental casts after 1-year retention.

Figure 17. Panoramic radiograph, lateral and posteroanterior cephalograms, and their tracings after 1-year retention.

Figure 1

Figure 2

Click here to access/download;Figure;Figure 2RR.tif



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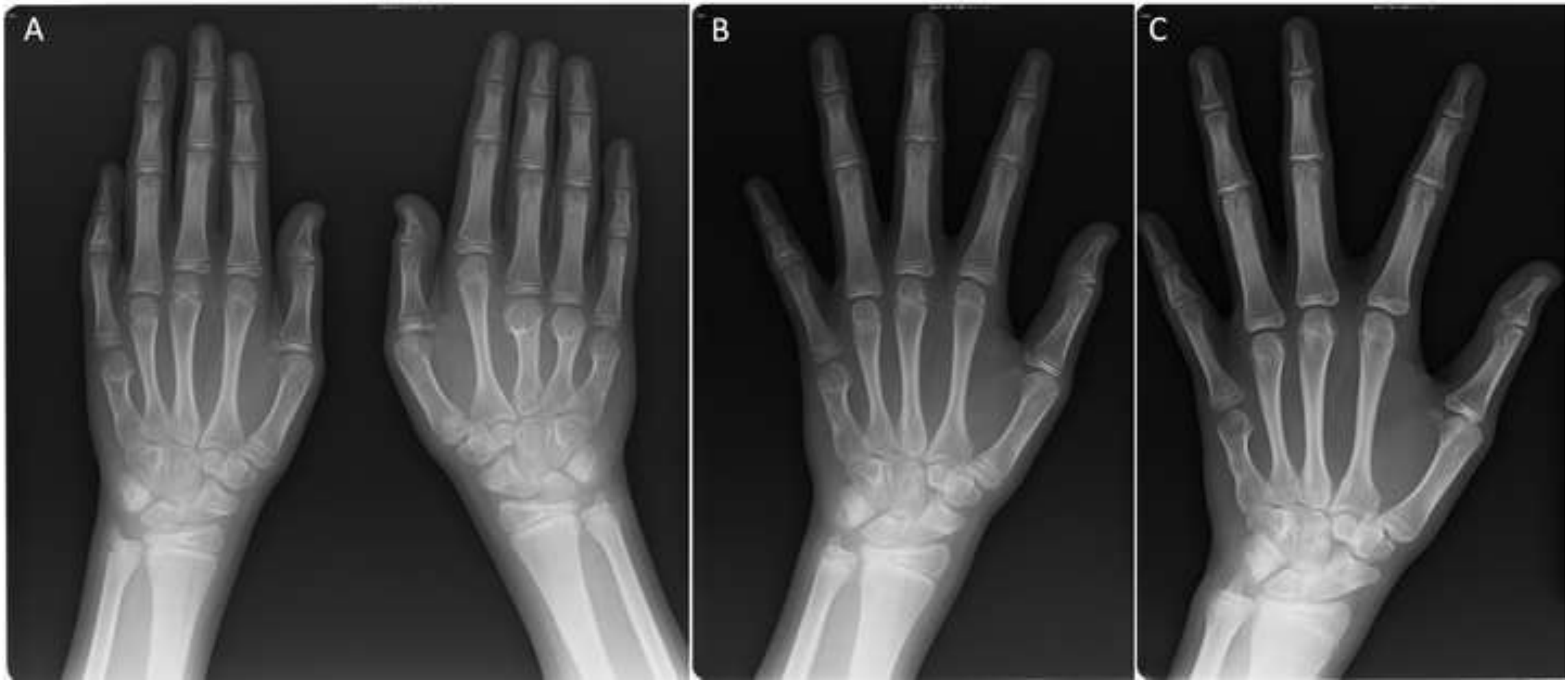

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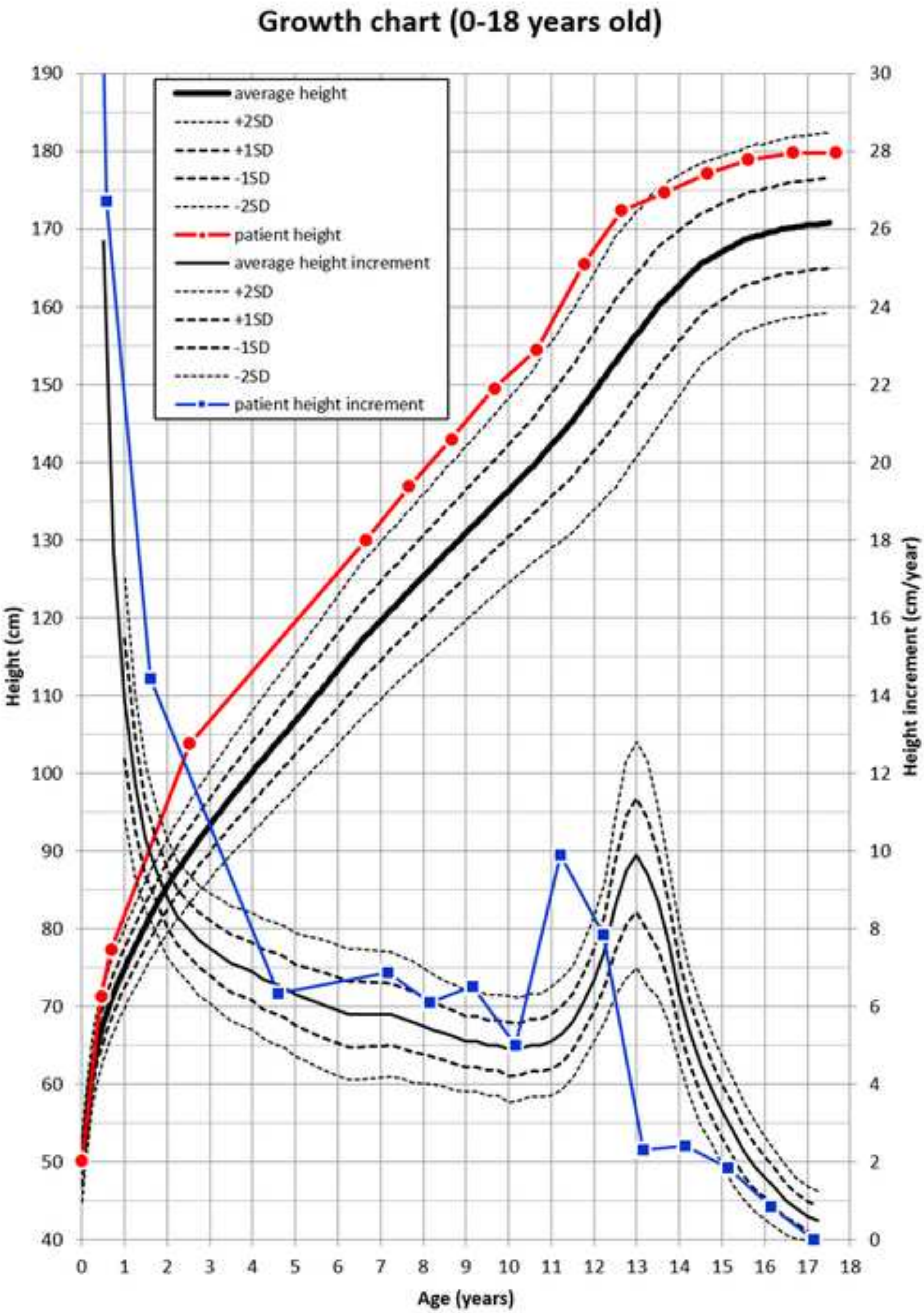
Growth chart (0-18 years old)
average height
+2SD
+1SD
-1SD
-2SD
patient height
average height increment
+2SD
+1SD
-1SD
-2SD
patient height increment
Height (cm)
Height increment (cm/year)
Age (years)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
28
26
24
22
20
18
16
14
12
10
8
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4
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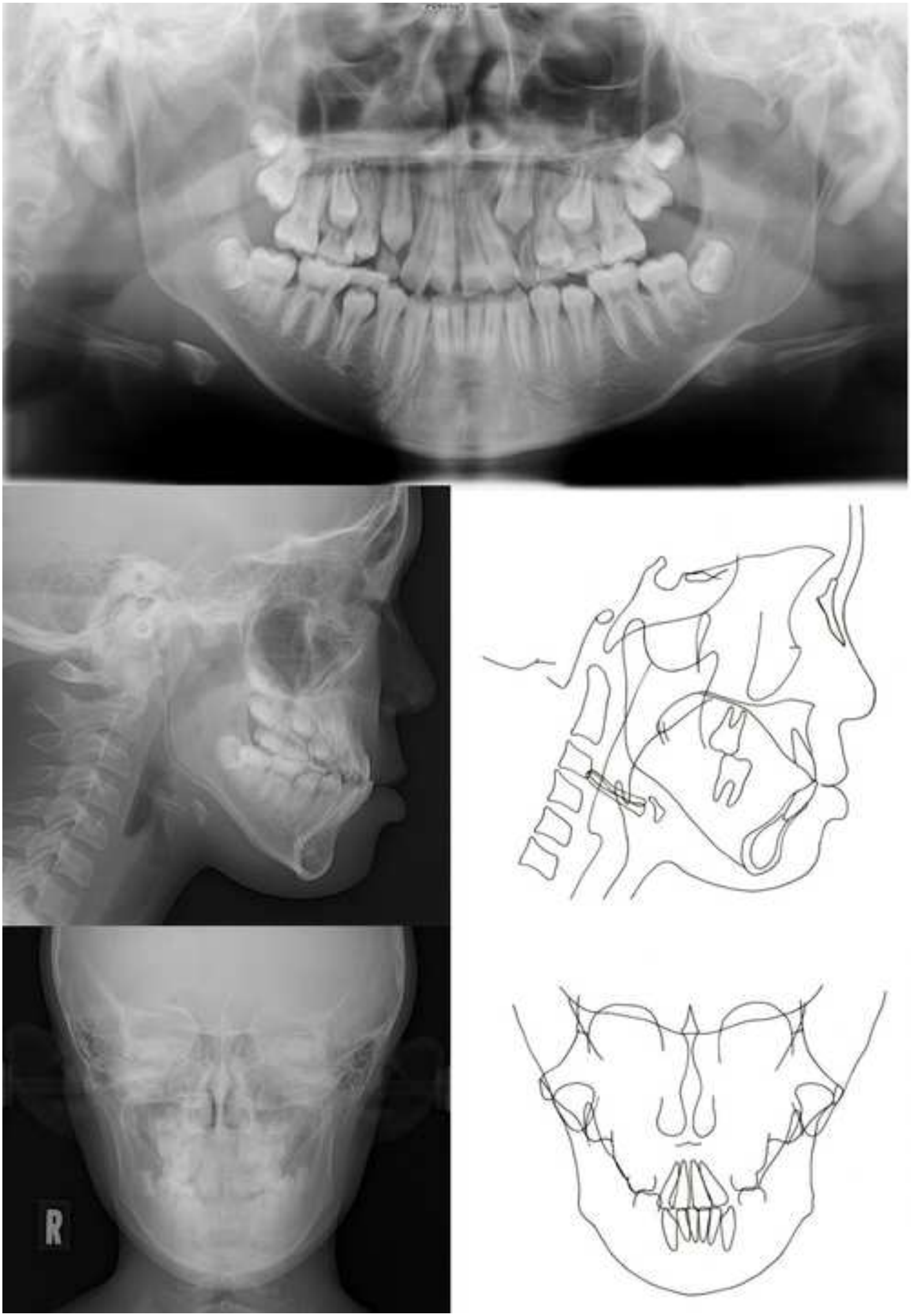
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Figure 5 Click here to access/download;Figure;Figure 5RR.tif



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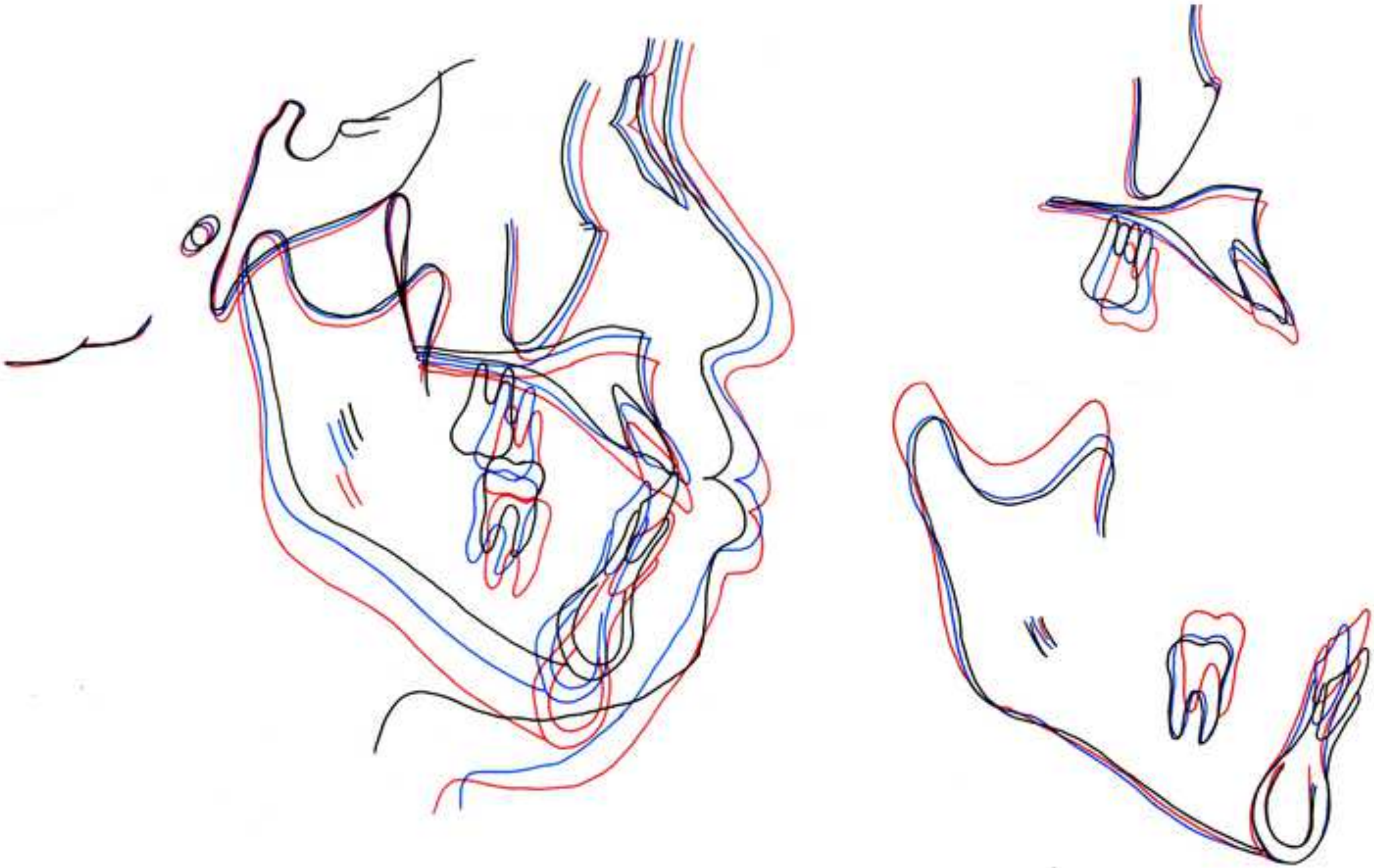

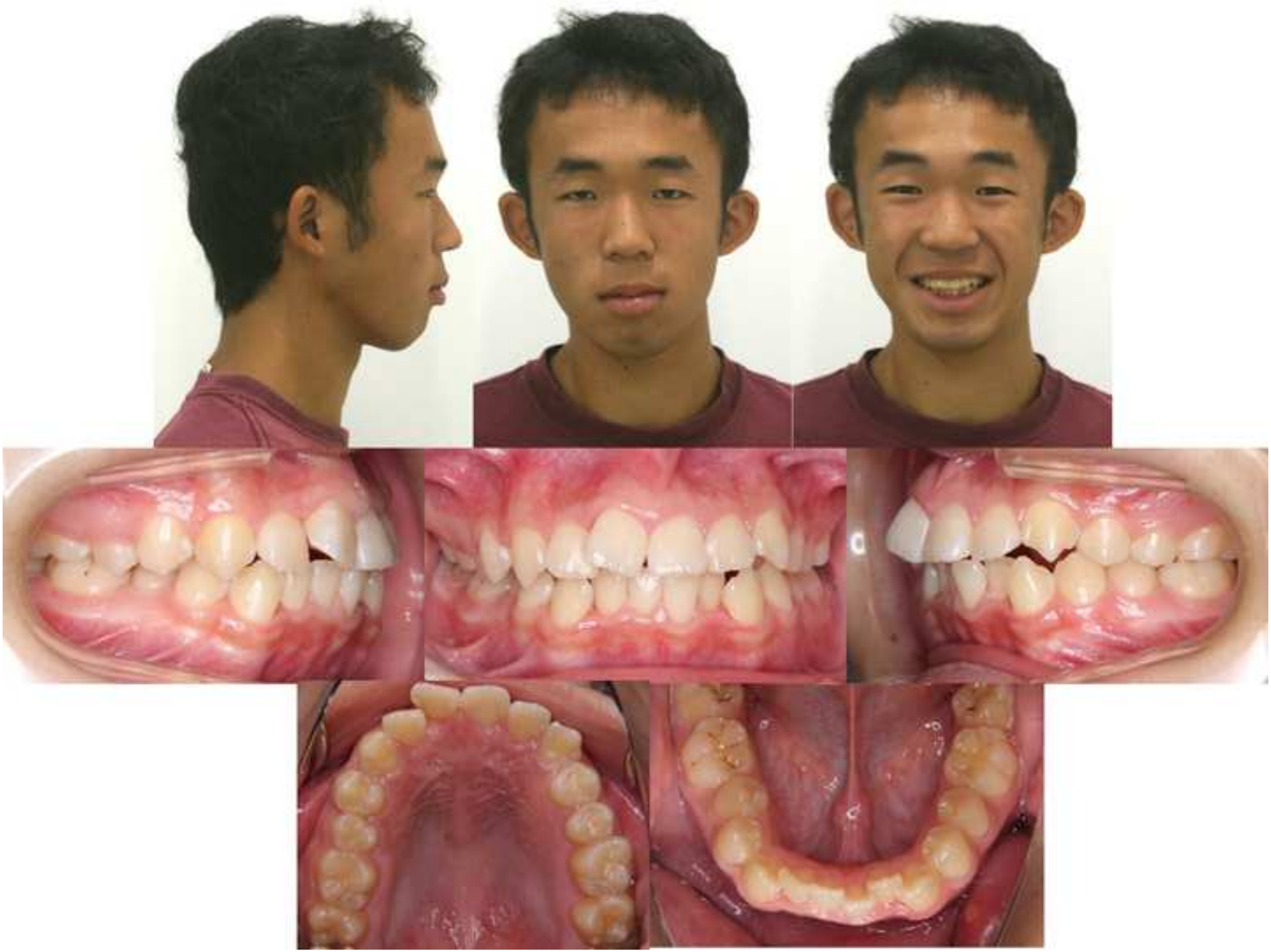

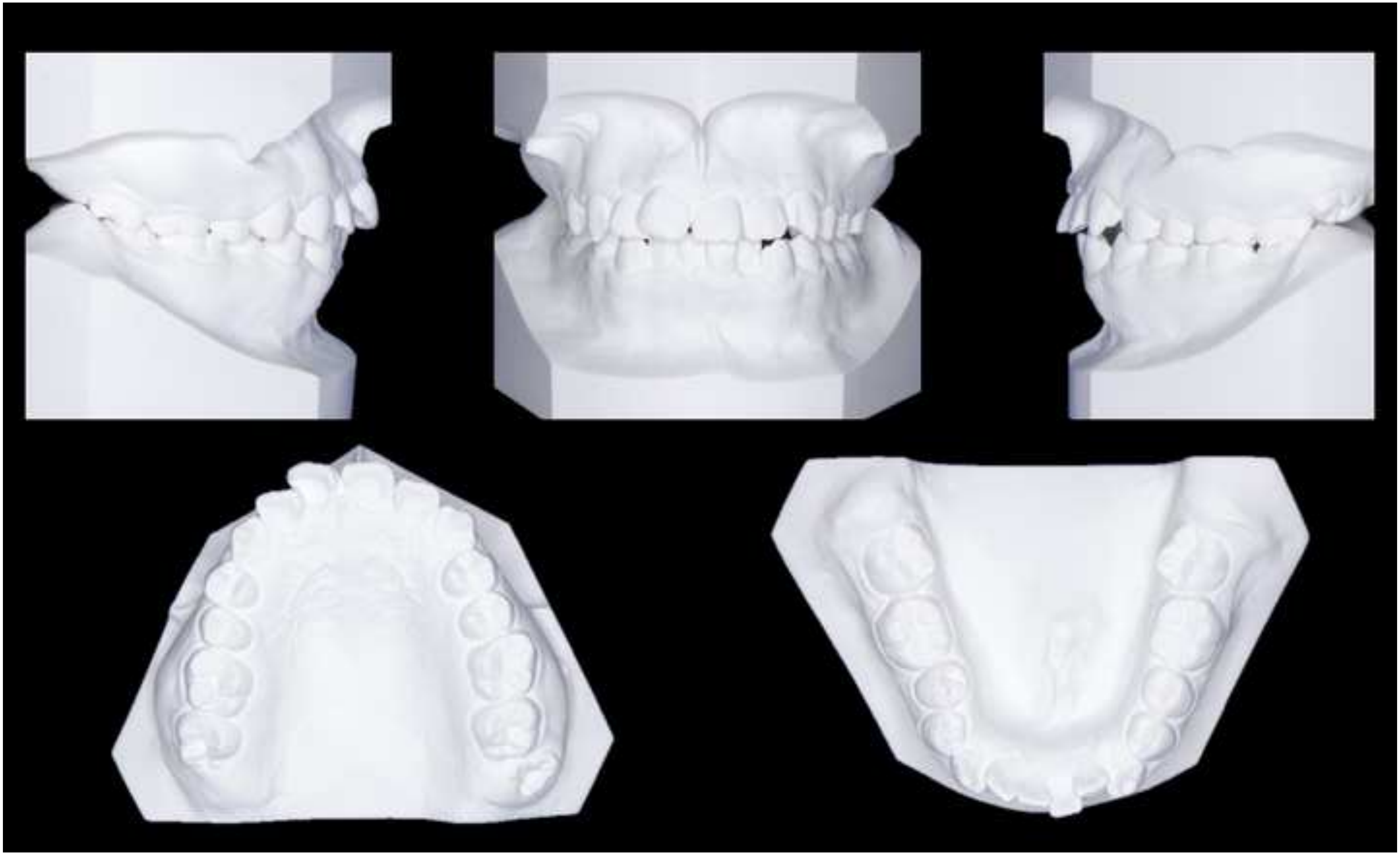

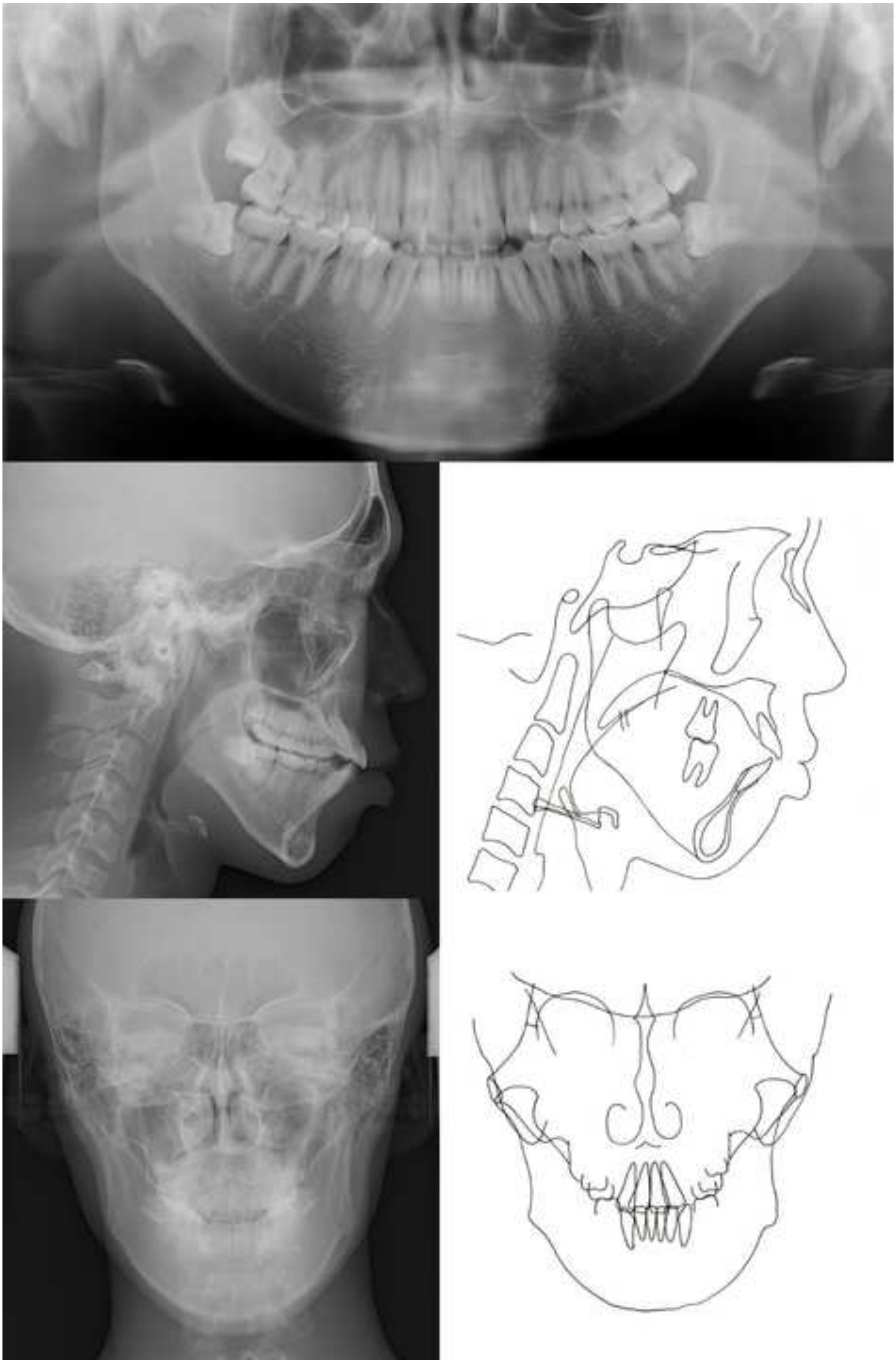

Figure 10

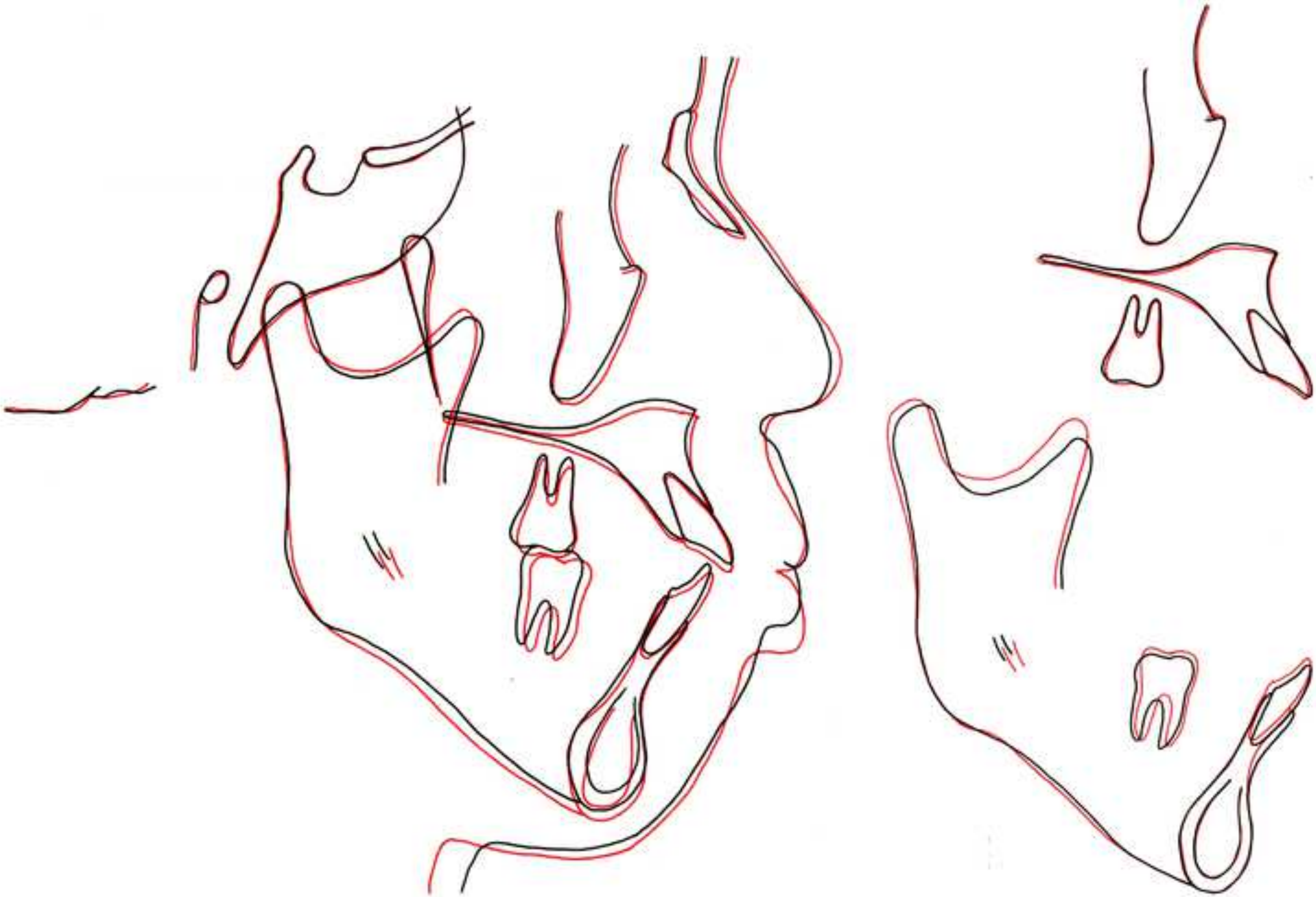

Figure 11 Click here to access/download;Figure;Figure 11RRRR.tif

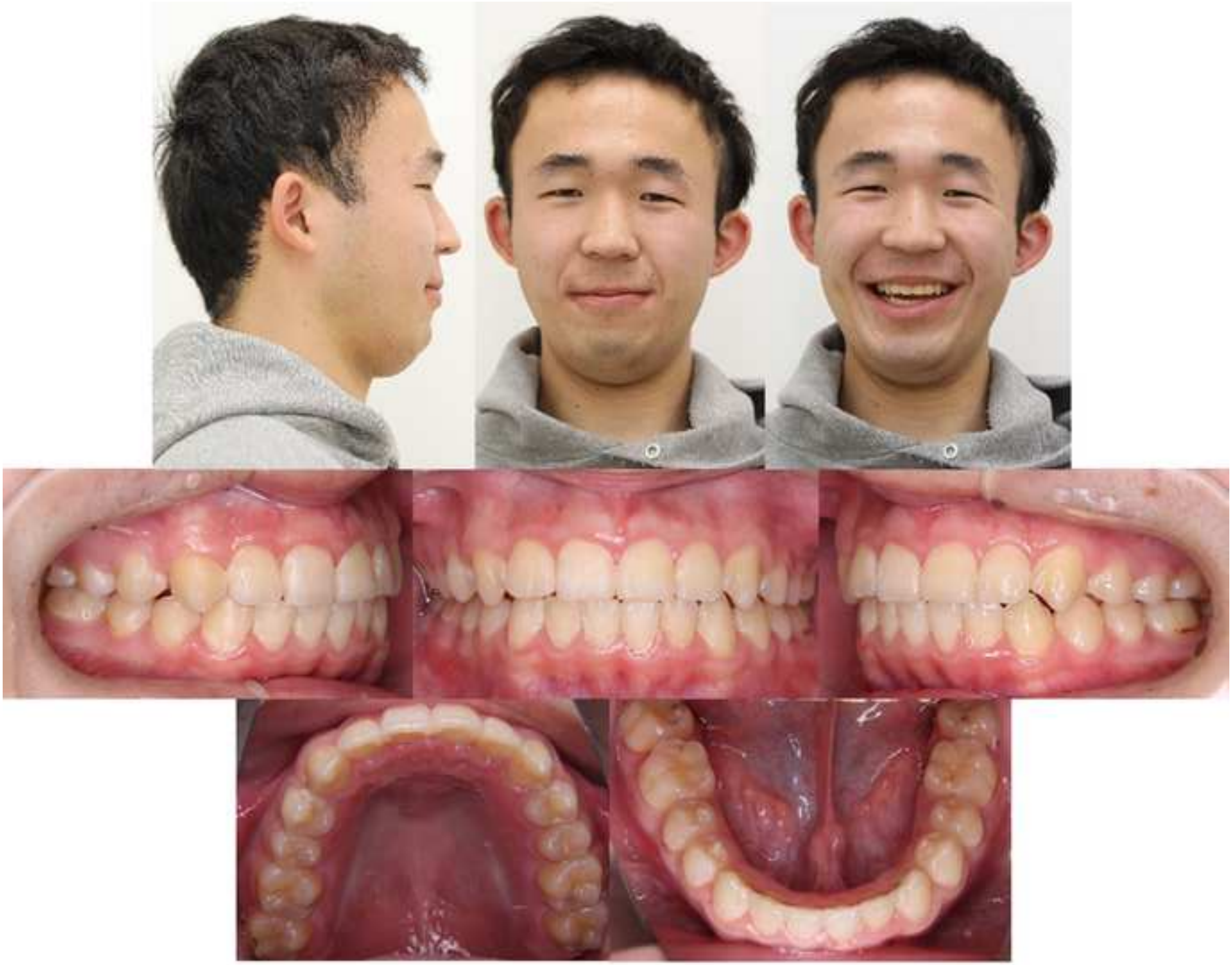

Figure 12

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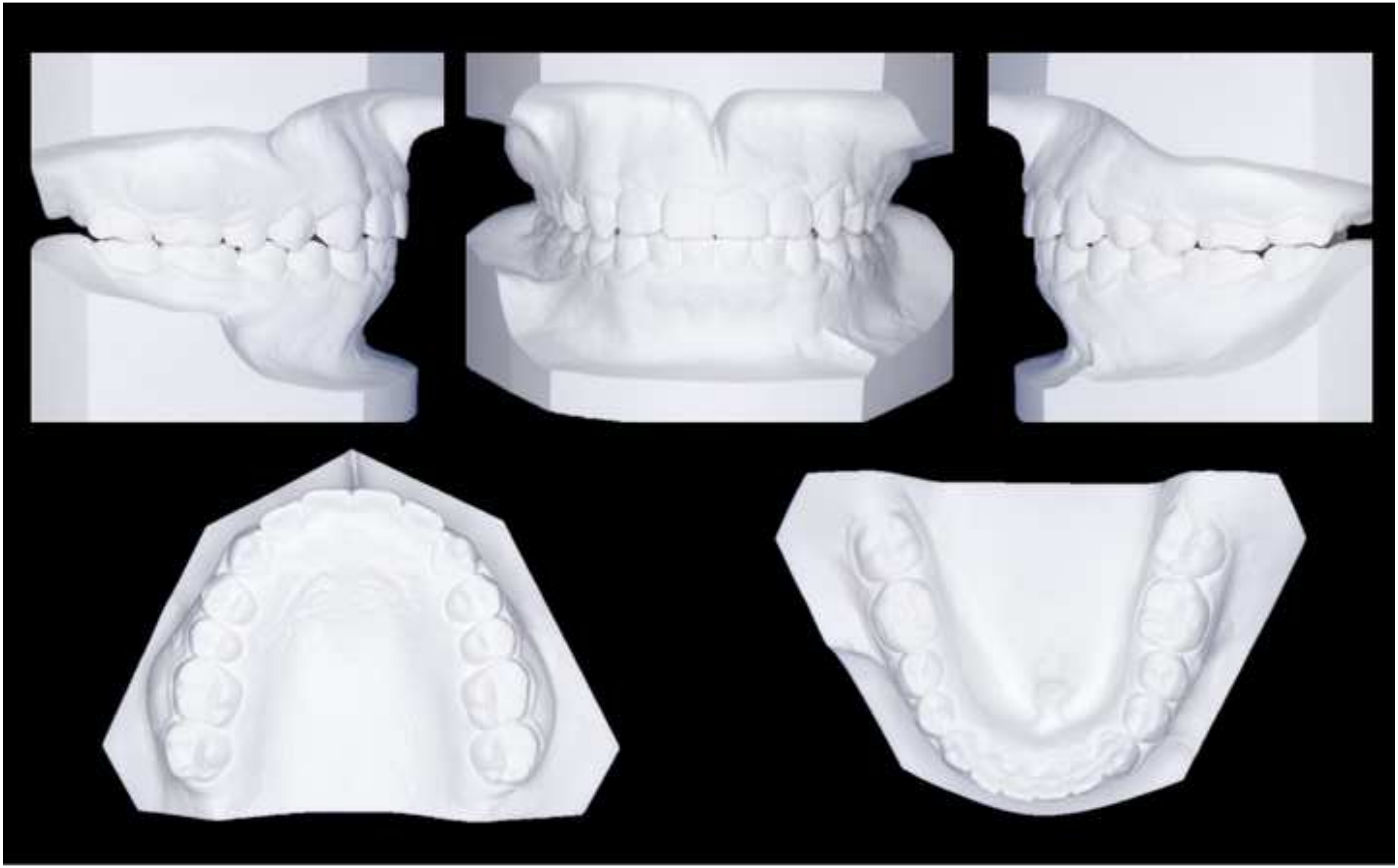


Figure 13

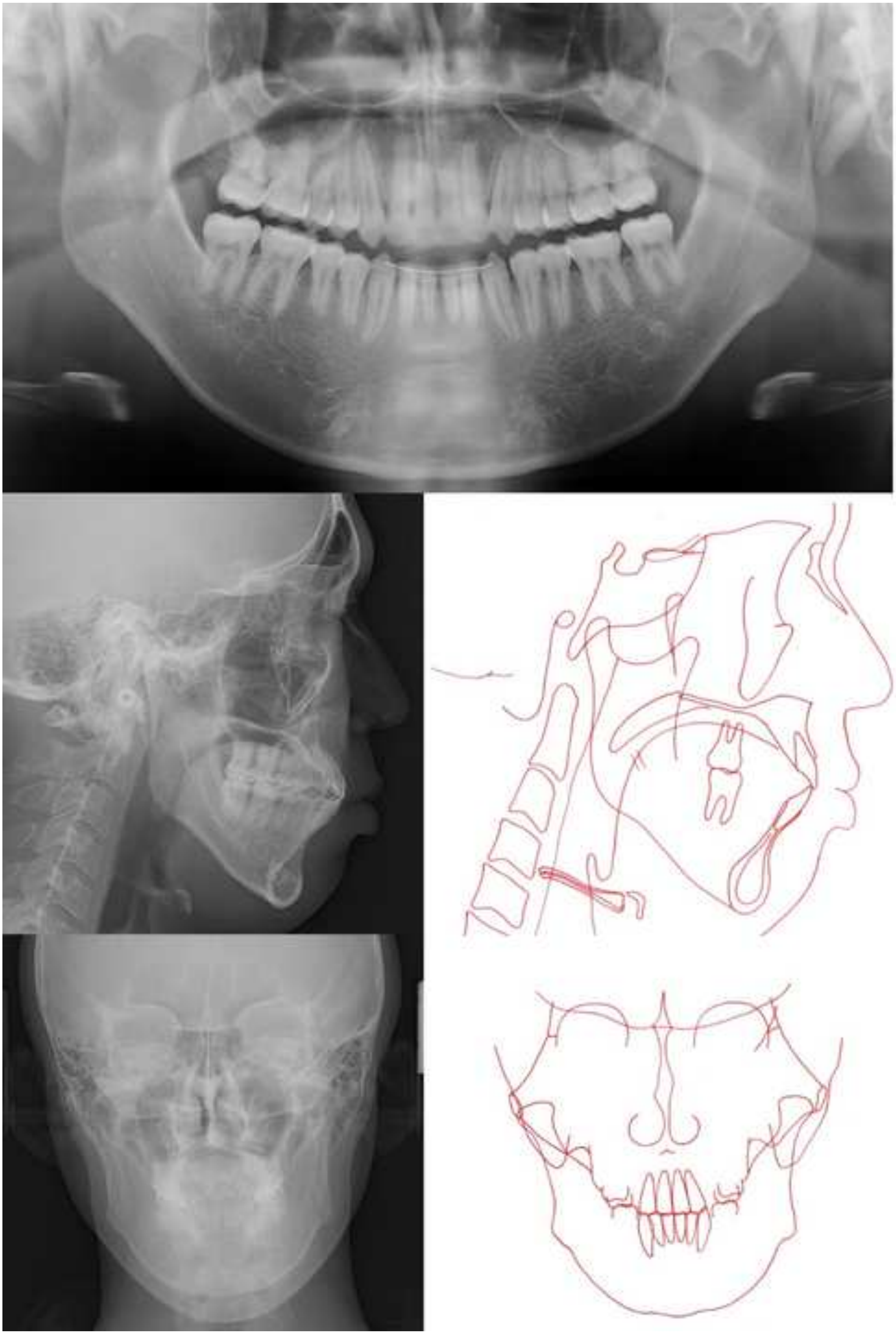
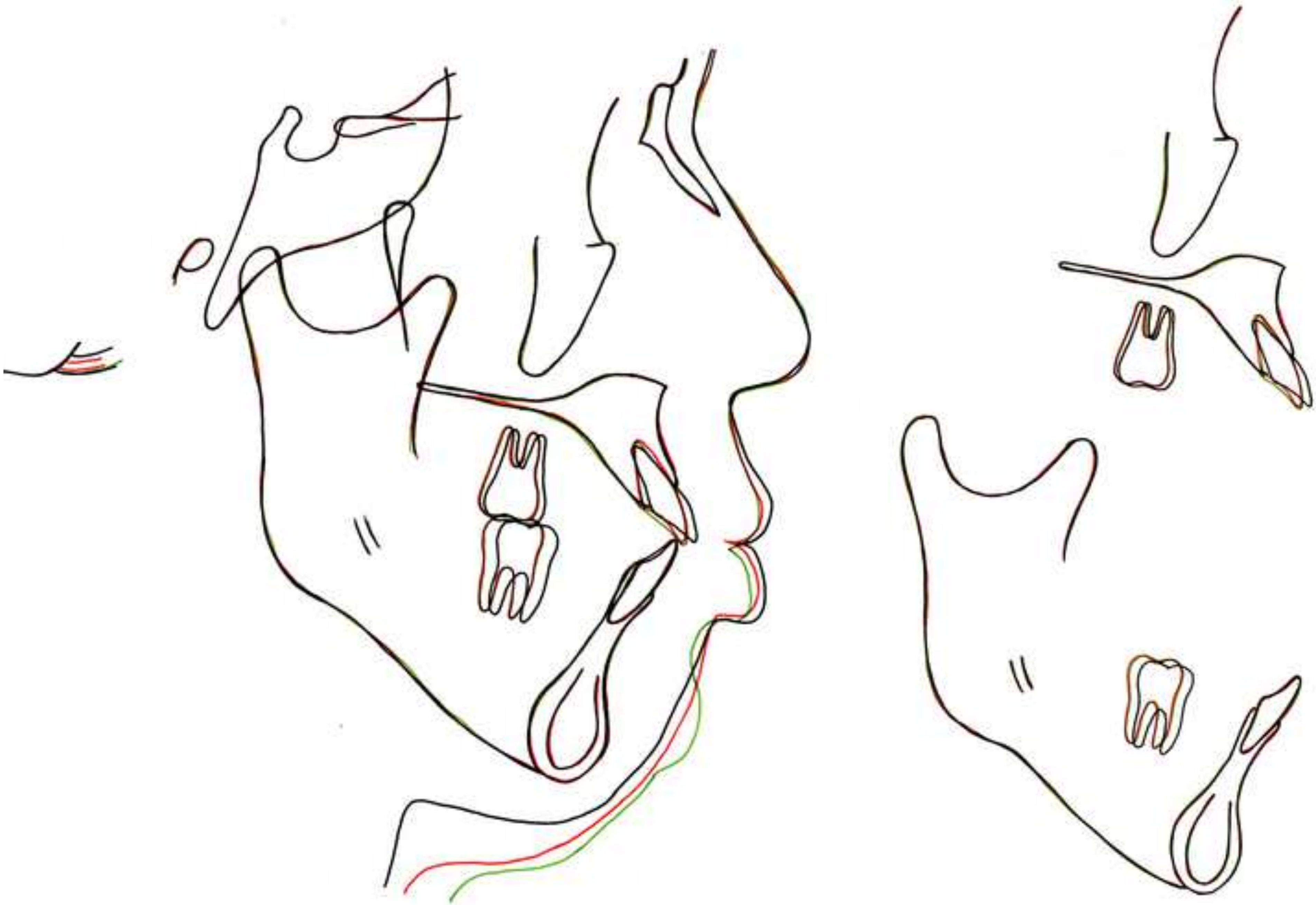


Figure 14



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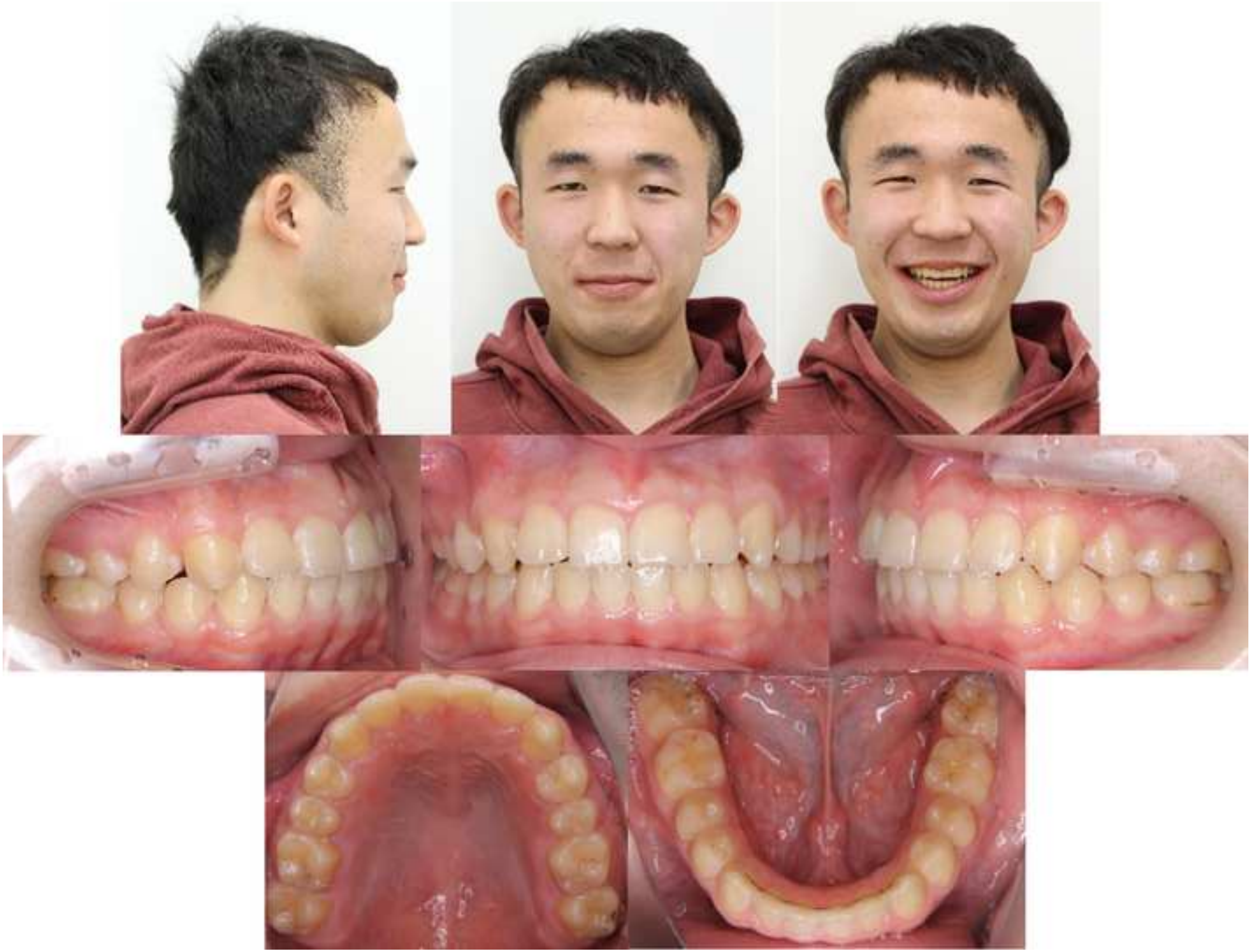
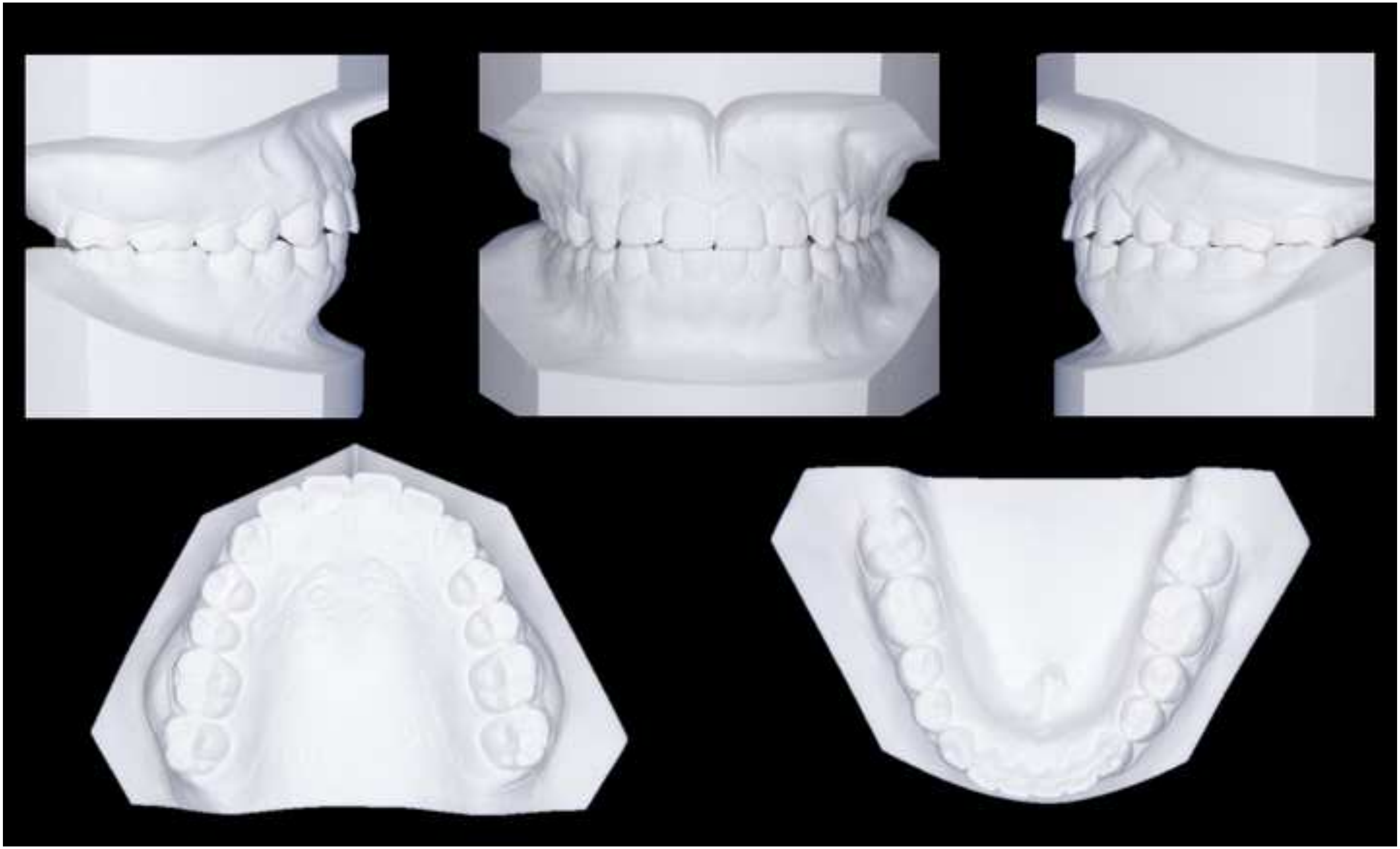


Figure 16



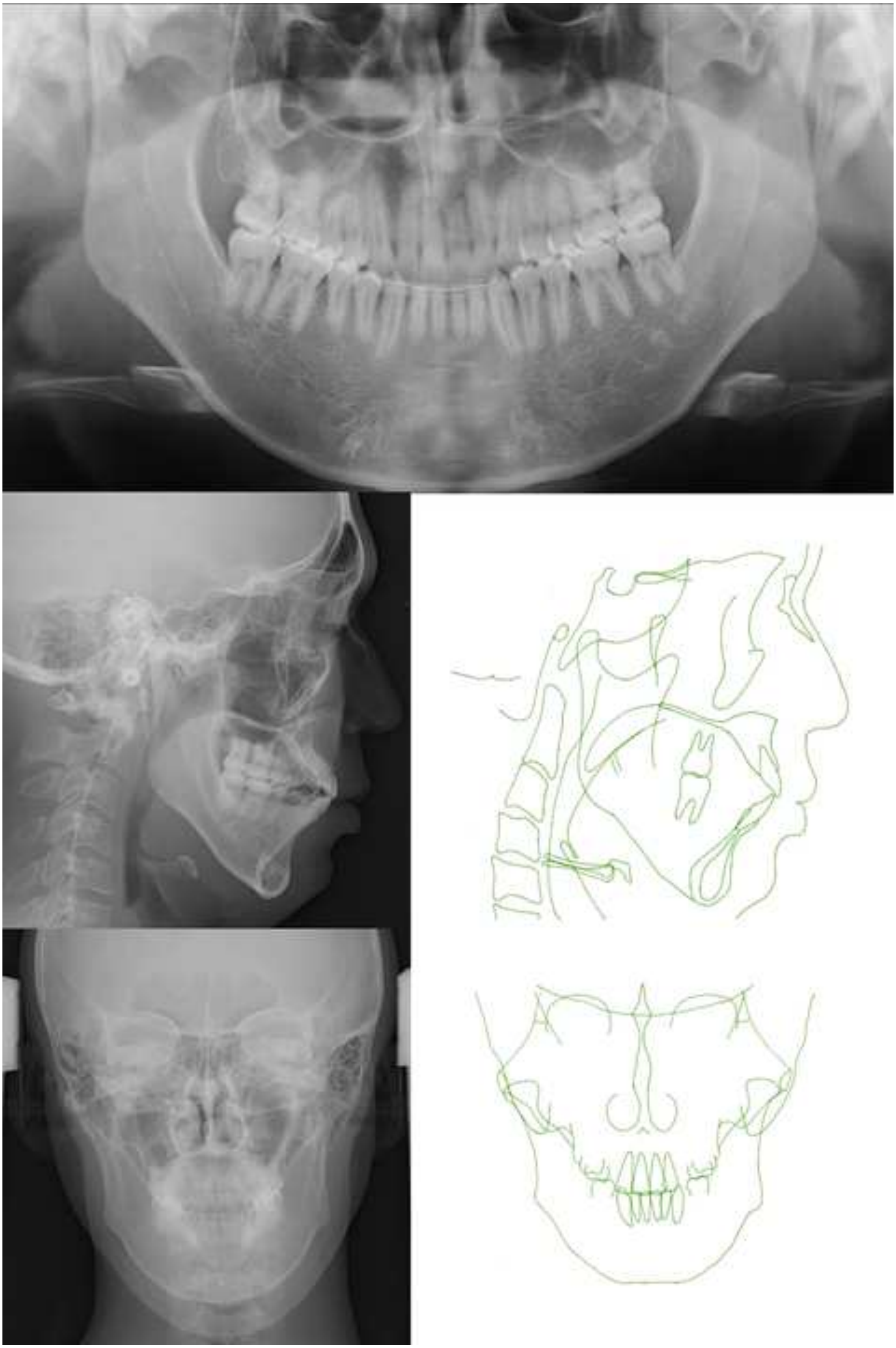


Table I. Lateral cephalometric summary

	Mean, Japanese male*								Pretreatment	After initial treatment	After phase 1 treatment	Before phase 2 treatment	Posttreatment	After 1 year retention
Variables	*10 y*	*SD*	*12 y*	*SD*	*14 y*	*SD*	*Adult*	*SD*	*10 y*	*11 y*	*14 y*	*16 y*	*19 y 6 m*	*20 y 6 m*
Angle (°)														
ANB	4.2	1.8	4.3	2.2	3.7	2.3	3.2	2.4	0.0	3.6	4.3	3.8	3.6	3.6
SNA	81.8	3.4	81.6	3.4	81.9	3.6	81.5	3.3	79.0	78.9	78.6	78.7	78.7	78.7
SNB	77.5	3.1	77.2	3.7	78.1	4.1	78.2	4.0	79.0	75.3	74.3	74.8	75.1	75.1
FMA	30.8	4.3	30.6	5.1	29.2	5.8	28.0	6.1	31.5	34.5	35.7	37.3	36.4	36.4
Gonial angle	126.3	5.2	125.0	5.9	123.3	6.6	120.9	6.5	134.3	132.5	131.6	133.9	133.8	133.8
U1-SN	104.1	5.6	105.0	7.1	106.6	8.5	106.0	7.5	110.2	116.1	112.0	111.8	102.8	104.9
L1-MP	93.2	6.8	95.7	5.4	96.7	6.0	95.2	6.2	87.3	77.5	91.0	90.3	89.9	90.0
Interincisal angle	125.3	11.2	122.2	8.8	120.8	8.9	124.2	8.6	119.9	120.3	110.0	110.2	120.6	118.4
Occlusal plane	19.3	3.7	17.9	3.2	16.1	3.3	15.5	4.2	16.6	13.8	16.0	15.9	16.4	17.0
Linear (mm)														
S-N	66.1	2.5	68.5	2.8	70.8	3.2	72.2	3.3	73.7	75.0	78.0	79.3	79.3	79.3
N-Me	116.3	4.1	123.4	4.7	130.5	4.7	135.7	4.0	131.2	136.9	148.3	150.7	150.4	150.4
Ar-Go	42.5	2.6	44.9	3.7	49.3	4.9	53.2	5.7	49.6	50.9	55.1	56.3	56.3	56.3
Go-Me	64.6	2.8	69.1	4.4	73.3	5.1	76.6	4.4	68.9	70.8	74.2	75.0	75.0	75.0
Ar-Me	97.7	3.0	103.4	5.9	110.5	6.8	115.6	6.8	111.4	111.6	120.7	121.7	121.7	121.7
Me/PP	63.1	3.3	66.6	3.3	71.0	3.4	74.6	3.0	72.6	74.2	81.9	83.7	83.4	83.4
Overjet	3.3	1.4	3.4	1.2	3.0	1.3	3.3	1.0	-1.7	7.0	3.6	3.9	1.3	1.4
Overbite	3.5	2.6	3.5	1.5	3.0	1.6	3.3	1.7	0.4	2.5	0.1	0.5	1.1	1.9

*Wada et al.[15]

ANB, Anteroposterior relation between the maxilla and mandible; SNA, Anteroposterior position of the maxilla relative to the anterior cranial base;
SNB, Anteroposterior position of the mandible relative to the anetrior cranial base; FMA, Divergency of the mandibular plane relative to Frankfort horizontal plane;
Gonial angle, angle between the mandibular and ramus planes; U1-SN, Maxillary central incisal axis to sella-nasion plane;
L1-MP, Mandibular central incisal axis to mandibular plane; Interincisal angle, angle between maxillary and mandibular central incisal axes;
Occlusal plane, occlusal plane angle to sella-nasion plane; S-N, Anteroposetrior length of the anterior cranial base; N-Me, Anterior facial height;
Ar-Go, Length of the mandibular ramus; Go-Me, Length of the mandibular corpus; Ar-Me, Total length of the mandible; Me/PP, Lower anterior facial height;

Table II

Click here to access/download;Table;Table II.xlsx

Table II. Frontal cephalometric summary

	Mean, Japanese male*								Pretreatment	After initial treatment	After phase 1 treatment	Before phase 2 treatment	Posttreatment	After 1 year retention
Variables	*10 y*	*CD*	*12 y*	*CD*	*14 y*	*CD*	*Adult*	*CD*	*10 y*	*11 y*	*14 y*	*16 y*	*19 y 6 m*	*20 y 6 m*
Denture midline (mm)	0.0	1.5	0.0	1.5	0.0	1.5	0.0	1.5	-3.4	-2.7	-2.7	-3.4	0.0	0.2
Maxillomandibular midline (°)	0.0	1.5	0.0	1.5	0.0	1.5	0.0	1.5	-5.2	-3.8	-4.0	-4.0	-3.5	-3.5
Occlusal plane tilt (mm)	0.0	1.1	0.0	1.1	0.0	1.1	0.0	1.1	-1.8	-0.6	-0.8	-1.1	-0.4	-0.4
Postural symmetry (°)	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0	1.0	2.0	1.8	0.2	0.6	0.6

*Nezu et al.[19] CD:Clinical deviation

Denture midline, Distance between the maxillary and madibular dental midlines

Maxillomandibular midline, The angle formed between the ZR-ZL plane and the ANS-ME plane

Occlusal plane tilt, Difference between the mesasurements from the ZR-ZL line to the occlusal plane at the level of left and right molars

Postural symmetry, Difference between angles ZL-AG-ZA on the left and ZR-AG-ZA on right side

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CASE REPORT: A case report of Sotos syndrome treated with non-surgical orthodontic technique

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