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Application of aligners for detailing and finishing biomechanics in “surgery first” approach

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Key words *aligners, Class III malocclusion, detailing and finishing, post-surgical orthodontics, skeletal anchorage, surgery first*

In a surgery first (SF) approach, no presurgical orthodontic treatment is carried out, and orthognathic surgery (OGS) is the first step in the correction of skeletal disharmonies. Once the OGS for the correction of skeletal problems is completed, post-surgical orthodontic treatment is required to correct transitional malocclusions with complex dental problems. Recently, in a move away from the use of fixed appliances in post-surgical orthodontic treatment in SF, a new option has been provided to support those patients who desire post-surgical orthodontic treatment with aesthetic and comfortable clear aligners. In this case report, a 24-year-old man with skeletal Class III malocclusion successfully underwent a SF approach followed by short-term fixed appliances, and aligner treatment for detailing and finishing.

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Introduction

Surgery first (SF) is an innovative surgical orthodontic approach for the correction of skeletal deformities. In this approach, no presurgical orthodontic treatment is carried out at all, and orthognathic surgery (OGS) is the first step in the correction of skeletal disharmonies. Thanks to OGS, the maxillomandibular relationship is corrected into skeletal Class I with a symmetrical face in the early stage of the treatment period. Once the OGS is completed, post-surgical orthodontics is required to correct the transitional skeletal Class I malocclusions with the complex dental problems these patients typically display.

In 2009, the first ever SF case in combination with the skeletal anchorage system (SAS) was reported by our team[1]. In the 9 years that have followed, there have been many other reports focused on a SF approach[2-8]. Some of these have been papers published by the present authors, some have been about our method, and others have been on a different method with a similar-sounding name.

The following are the major advantages of SF compared to a conventional approach:

- the facial profile is improved in the early days after OGS;
- the total treatment time is significantly shorter;
- orthodontic decompensation is efficient and effective because of the biological effects derived from the natural force provided by lips and tongue;

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- tooth movement appears to be accelerated by the regional acceleratory phenomena (RAP).

Recently, we began to provide a new option in SF to support those patients who voice their preference for aligners over fixed appliances in the post-surgical orthodontic treatment stage. At the present time, our advice to these patients has been to reduce the fixed appliance treatment and then switch to aligners for detailing and finishing.

This article illustrates a new treatment option in the treatment of a skeletal Class III patient who first underwent OGS, and then spent a short period of time undergoing postoperative fixed appliance treatment with SAS before switching to aligner treatment in combination with microvibration.

Diagnosis and treatment plan

A 24-year-old male patient presented with the chief complaint of dissatisfaction with his facial appearance, and desired no presurgical orthodontics, short treatment time and treatment with invisible orthodontic appliances. Initial examination revealed mandibular excess, short lower facial height, Class III denture, proclination of maxillary incisors, retroclination of mandibular incisors, deviation of mandibular midline and difficulty in incising (Figs 1 and 2).

According to these orthodontic problems, and particularly the mandibular excess, mandibular setback osteotomy was clearly indicated. Since the patient's maxillary incisor display and interlabial gap were in the normal range, two-jaw surgery was not indicated.

Two-dimensional (2D) paper surgery and three-dimensional (3D) image predictions were used to establish the treatment goals (Fig 3). The 2D and 3D predictions indicated the need for about 10 mm of mandibular setback. Subsequent to mandibular setback by bilateral sagittal split ramus osteotomy (BSSO), his occlusion was predicted to change from Cass III to Class II with severe open bite (Fig 3a and b). Since no presurgical orthodontic treatment is carried out at all in the SF approach adopted in our clinic, a large overjet immediately after OGS reveals the true extent of incisor decompensation. In the post-surgical orthodontic treatment stage, it was planned to retrocline the maxillary incisors by about 5 mm after the distalisation of the maxillary posterior teeth using SAS without premolar extraction. At the same time, the decompensation of the mandibular incisors was planned by the mesialisation of the entire mandibular dentition using orthodontic miniplates, which were to be installed between the second premolars and first molars at the mandibular body.

Although the patient expressed his wish to undergo post-surgical orthodontic treatment with aligners throughout the whole treatment period, short-term treatment with fixed appliances in combination with SAS was recommended to manage rapid occlusal changes and unstable occlusion.

Treatment progress

Orthognathic surgery

About 6 months prior to OGS, all of the third molars (teeth 18, 28 and 48) were extracted. Cast surgery was set up according to the treatment goals, and a specific surgical splint with a lingual bar and four ball end clasps for the mandibular first molars was fabricated (Fig 4a). Since presurgical orthodontic treatment was eliminated in SF, the occlusion immediately after OGS is unstable. Therefore, a surgical splint is essential to stabilise the bone segments and the temporomandibular joint (TMJ). A surgical splint for SF is designed to cover only the occlusal surface of the bimaxillary lateral teeth to avoid problems with breathing and drinking. Shortly before OGS, eight hooks were bonded at all canines and the first premolars for the placement of the training elastics postoperatively. No bracket was bonded before OGS (Fig 4b).

The modified BSSO[9] was then carried out to achieve the required mandibular setback. T-shaped titanium bone plates were used for rigid internal fixation, and four orthodontic miniplates were put in place at the zygomatic buttress and the mandibular body bilaterally at the same time (Fig 4b). In addition, four miniscrews were installed at the bimaxillary anterior alveolar regions to avoid unwanted extrusion of incisors. A surgical splint was placed for stabilisation of bone segments and the TMJ. One day following OGS, up and down training elastics were placed at the canines and first premolars bilaterally (Fig 4b).

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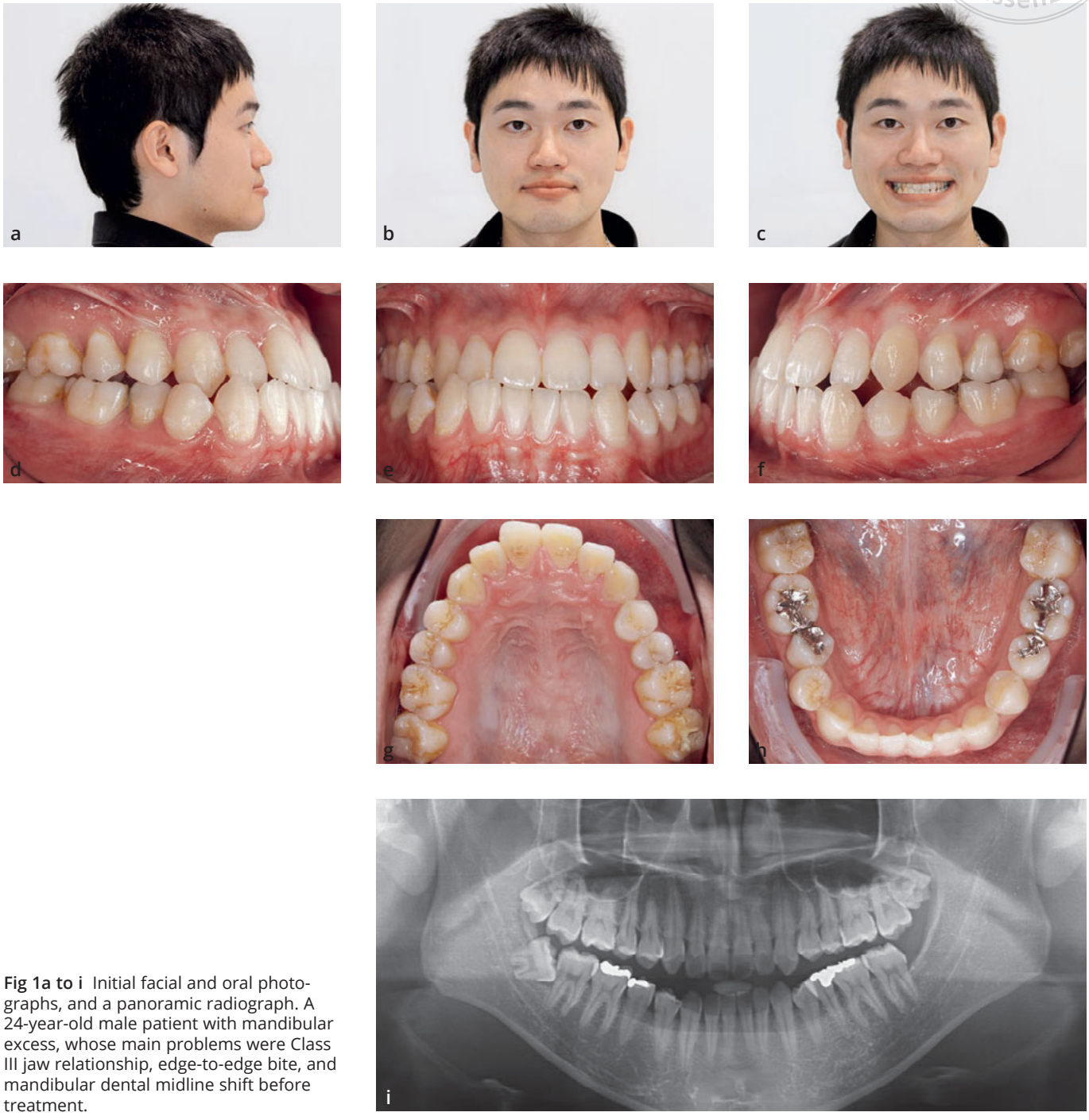

Fig 1a to i Initial facial and oral photographs, and a panoramic radiograph. A 24-year-old male patient with mandibular excess, whose main problems were Class III jaw relationship, edge-to-edge bite, and mandibular dental midline shift before treatment.

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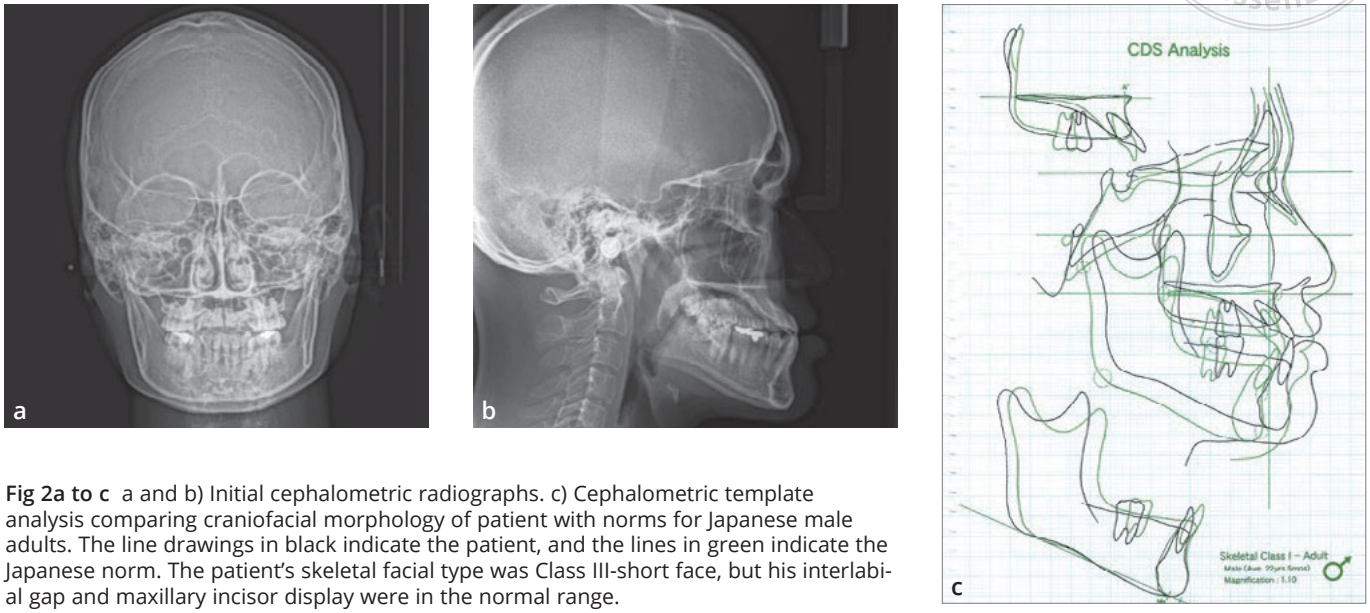

Fig 2a to c a and b) Initial cephalometric radiographs. c) Cephalometric template analysis comparing craniofacial morphology of patient with norms for Japanese male adults. The line drawings in black indicate the patient, and the lines in green indicate the Japanese norm. The patient's skeletal facial type was Class III-short face, but his interlabial gap and maxillary incisor display were in the normal range.

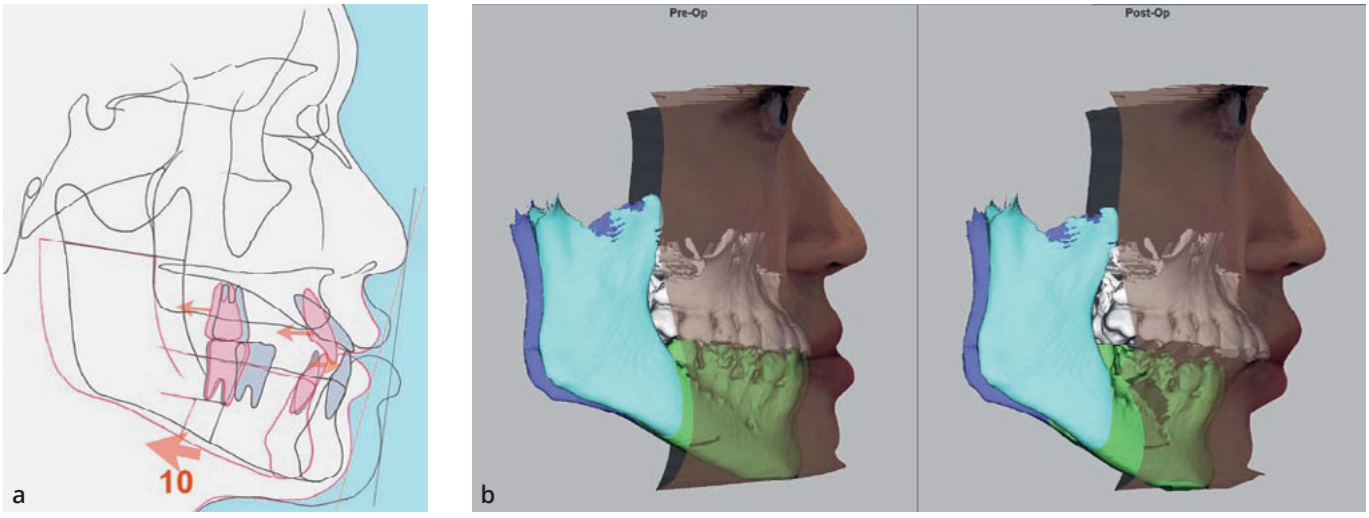

Fig 3a and b a) Cephalometric prediction of treatment results immediately after orthognathic surgery and after orthodontic treatment with target dentofacial positions shown in red. b) 3D image prediction compared with before and immediately after orthognathic surgery. Subsequent to 10-mm setback of the mandible by bilateral sagittal split ramus osteotomy (BSSO), his occlusion changed from Class III to Class II - open bite.

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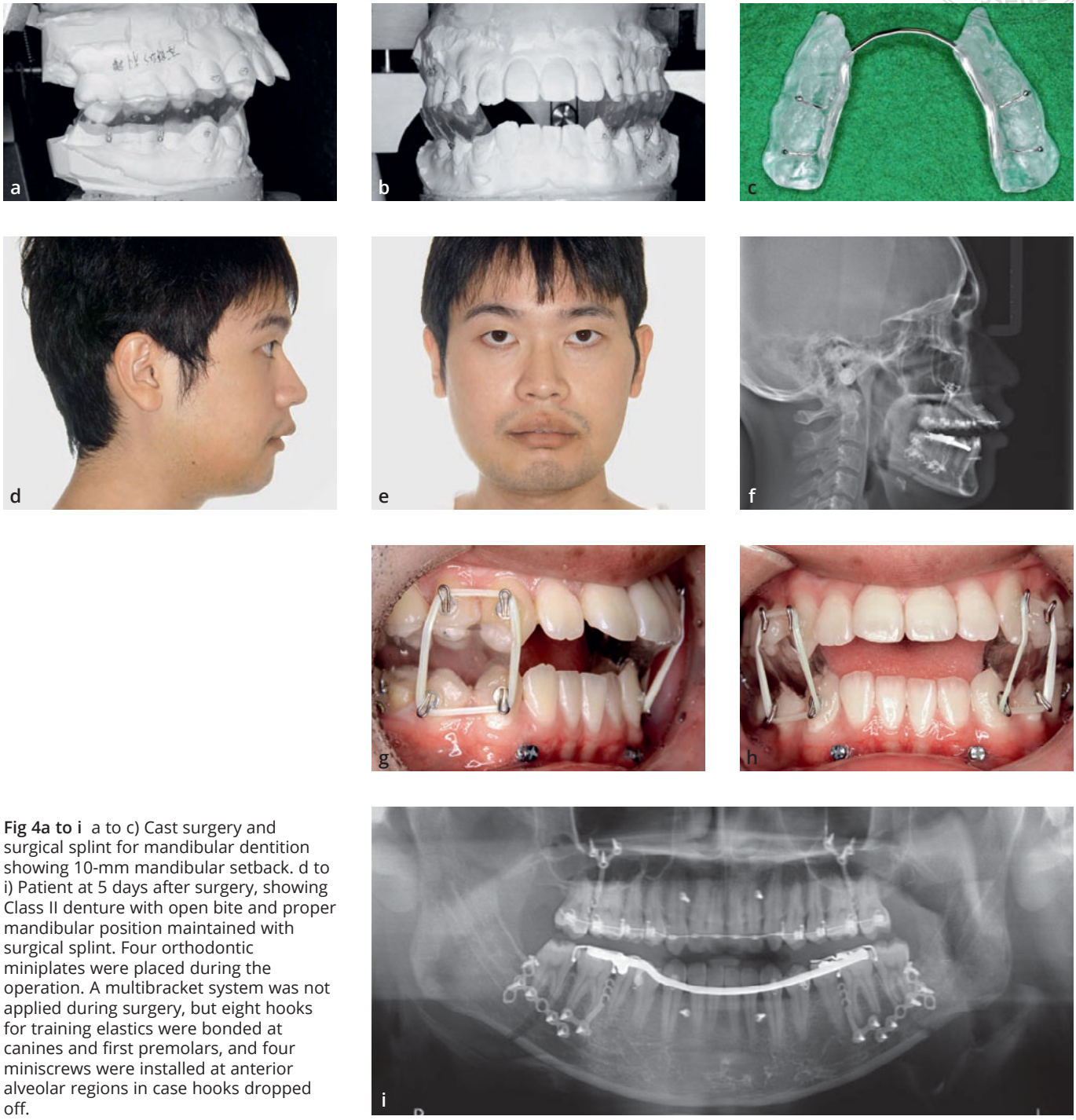

Fig 4a to i a to c) Cast surgery and surgical splint for mandibular dentition showing 10-mm mandibular setback. d to i) Patient at 5 days after surgery, showing Class II denture with open bite and proper mandibular position maintained with surgical splint. Four orthodontic miniplates were placed during the operation. A multibracket system was not applied during surgery, but eight hooks for training elastics were bonded at canines and first premolars, and four miniscrews were installed at anterior alveolar regions in case hooks dropped off.

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Fig 5a to l Treatment progress of skeletal anchorage system. a to c) 5 days after orthognathic surgery (OGS). Brackets were bonded in the maxillary dentition. Levelling and distalisation of the maxillary posterior teeth started with SAS. d to f) 1.5 months after OGS. Distalisation of the maxillary posterior teeth continued. g to i) 2.5 months after OGS. Brackets were bonded in the mandibular dentition. The occlusal splint had already been discontinued. Distalisation of the maxillary molars continued and cross elastics were put in place at the canines and first premolars. j to l) 3.3 months after OGS. Distalisation of the maxillary right molars and the application of cross elastics continued.

Post-surgical orthodontics with SAS

Five days after OGS, brackets were bonded in the maxillary dentition, and levelling was started using 0.016″ × 0.022″ CuNiTi wire in combination with the occlusal splint and training elastics (Fig 5a to c). At the same time, the distalisation of the maxillary molars was started along the occlusal plane. The occlusal splint was arranged by flattening the occlusal surface of the surgical splint in order to facilitate the movement of the maxillary posterior teeth. The distalisation of the maxillary molars utilizing SAS continued until the brackets were debonded (Fig 5a to l). The splint was discontinued 2.5 months after OGS and brackets were placed in the mandibular dentition, and then transverse decompensation (dental arch coordination) was started with the application of cross elastics at the canine and first premolar regions (Fig 5g to l). Since his Class II denture with

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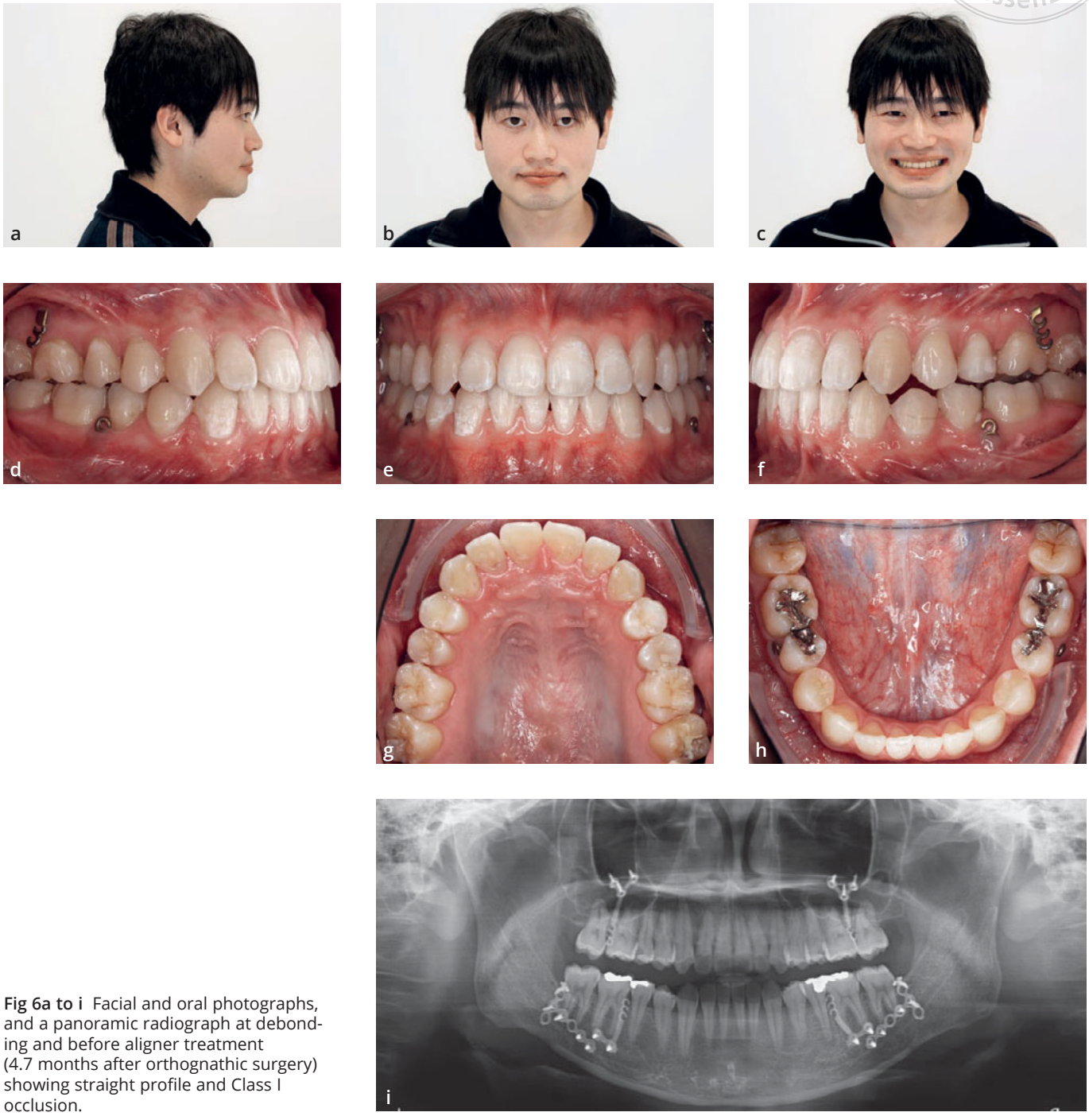

Fig 6a to i Facial and oral photographs, and a panoramic radiograph at debonding and before aligner treatment (4.7 months after orthognathic surgery) showing straight profile and Class I occlusion.

open bite was corrected into almost Class I denture in just 3.3 months after OGS (Fig 5j to l), it was decided that, although earlier than expected, it would soon be time to change to aligner treatment.

Post-surgical orthodontics with aligners

At 4.7 months after OGS, all of the brackets were debonded and vacuum-formed retainers were temporarily put into place in the bimaxillary dentition (Fig 6). At the same time, his dentition was scanned with a digital oral scanner (iTero; Align Technology, San Jose, CA, USA). Figure 7 shows the

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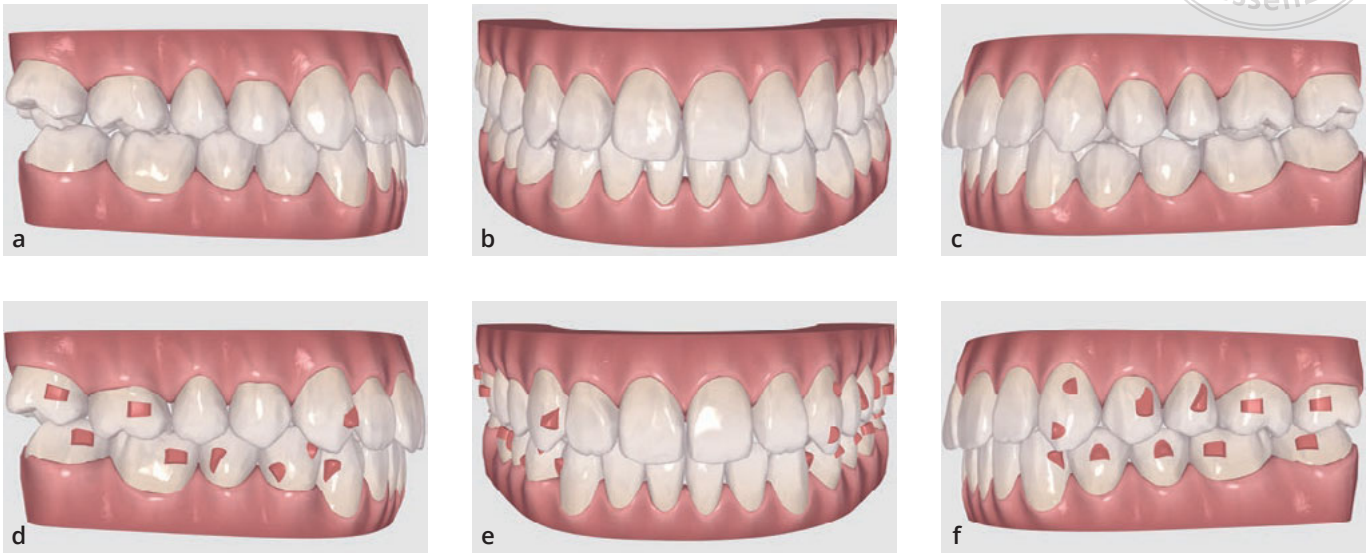

Fig 7a to f ClinCheck simulation: a to c) initial, d to f) final.

Fig 8a to f First aligner treatment started at 5.4 months after surgery. Micro-vibration (AcceleDent) was applied and instructed to use for 20 hours per day.

initial and final ClinCheck simulation (Align Technology) for aligner treatment. With the application of aligners (Invisalign; Align Technology), it was aimed to carry out the detailing and finishing stage of post-surgical orthodontic treatment in SF more precisely and invisibly than is possible when using fixed appliances. Aligner treatment with micro-vibration (AcceleDent; OrthoAccel Technologies, Bellaire, TX, USA) was started at 5.4 months after OGS (Fig 8). In this case, a series of 26 aligners was used both in the maxillary and the mandibular dentition. According to the conventional protocol (2-week change regimen and wearing at least 20 hours per day), it was expected that treatment would take 13 months, but thanks to micro-vibration, the actual treatment time was significantly reduced to about 4 months by changing aligners every 4 days.

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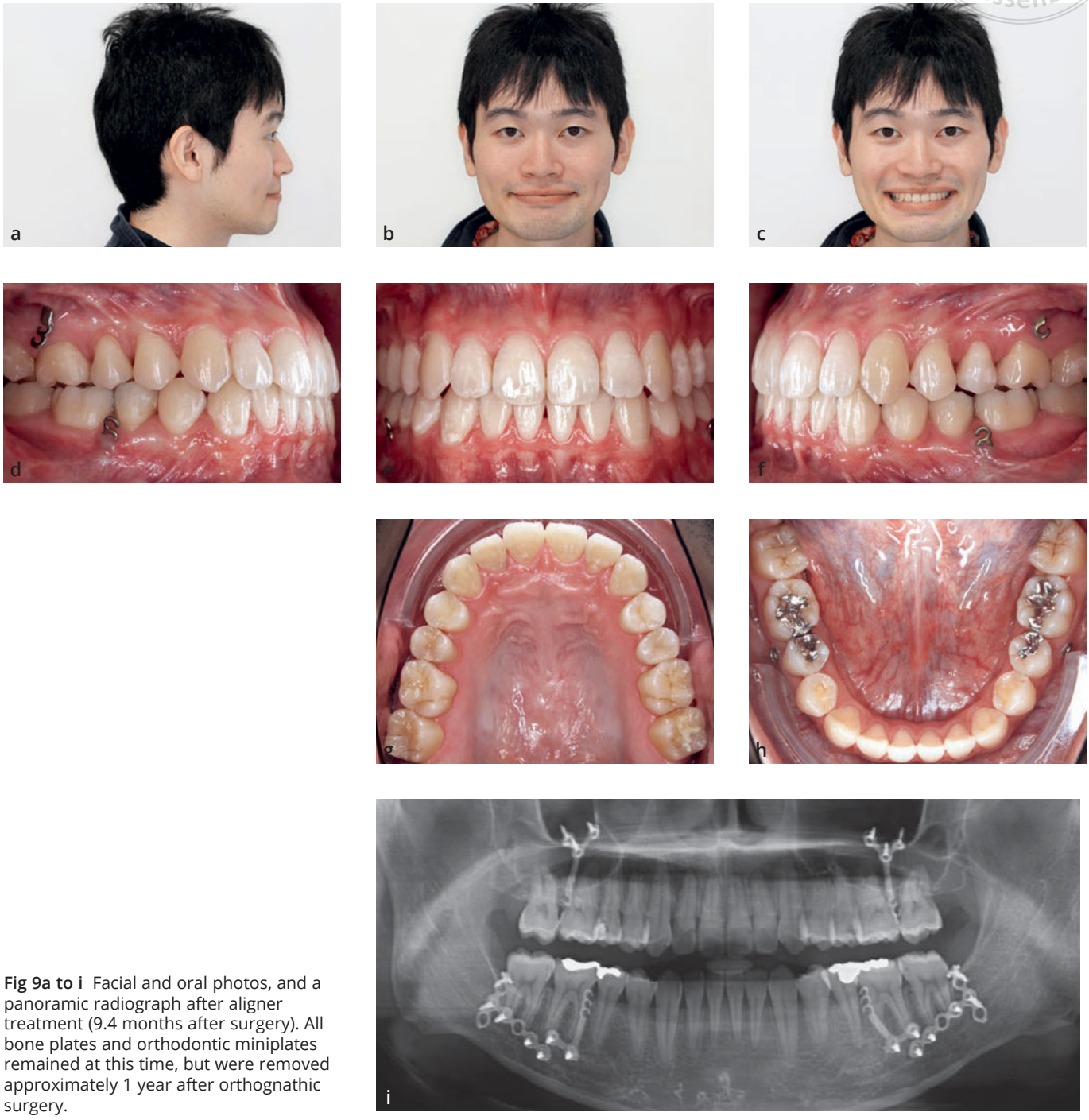

Fig 9a to i Facial and oral photos, and a panoramic radiograph after aligner treatment (9.4 months after surgery). All bone plates and orthodontic miniplates remained at this time, but were removed approximately 1 year after orthognathic surgery.

Treatment results

At 9.4 months after OGS, aligner treatment was completed and retention was started with retention aligners (Fig 9). The treatment time of aligners with micro-vibration was just 4.7 months. Thanks to SF and following fixed appliance biomechanics with SAS and aligner treatment, the patient's skeletal and dental problems were satisfactorily corrected in a short period of time. The bone plates and orthodontic anchor plates were removed approximately 1 year after OGS.

The cephalometric radiographs taken immediately after aligner treatment are shown in Fig 10. According to the lat-

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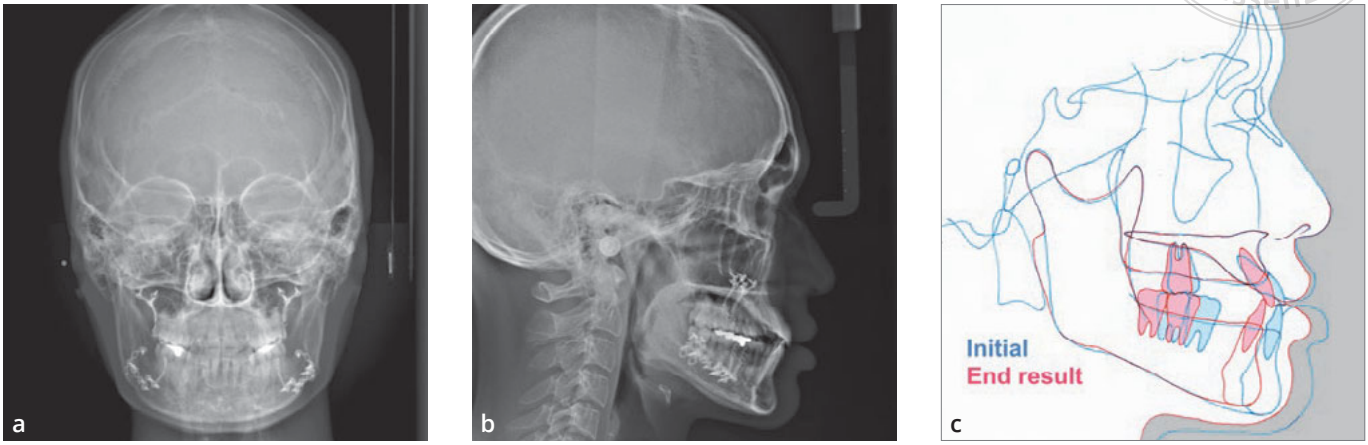

Fig 10a to c a and b) Cephalometric radiographs after Invisalign treatment. c) Lateral cephalometric superimposition before and after treatment. The mandible was properly displaced backward as planned and the maxillary incisor decompensation was carried out following distalisation of the maxillary posterior teeth.

eral cephalometric superimposition before and after treatment, the mandibular setback was carried out as planned with BSSO and the maxillary incisor decompensation was completed following distalisation of the maxillary posterior teeth with SAS. By this stage, his facial appearance and occlusion had drastically improved.

Figure 11 shows facial and oral photographs and a panoramic radiograph at the 2-year follow-up. The patient maintained a good profile and occlusion during the short-term post-treatment period.

Discussion

Many jaw deformity patients desire quick improvement of their facial appearance, short treatment time and orthodontic treatment without non-aesthetic fixed appliances. Following the development of SF, it has become possible to improve facial appearance at the first step of the treatment period, and significantly reduce the total treatment time involved in surgical orthodontics in comparison with that required by the conventional approach. There have been some reports on the application of aligners to presurgical and post-surgical orthodontics in conventional surgical orthodontics[10-13], but no paper could be accessed that reported on the application of aligners to the SF approach.

This paper details the case of a Class III patient who underwent SF in combination with short-term fixed appliances and aligners for detailing and finishing. This patient was clear in his request to have as much of his post-surgical orthodontics as possible done with aligners, but instead short-term therapy with fixed appliances in combination with SAS was recommended to manage rapid dental and occlusal changes immediately after OGS.

The current SF approaches can be classified into two rather different styles. One is the orthodontics-driven style, in which skeletal problems are solved by OGS, and dental problems are fixed orthodontically. The other is the surgery-driven style, in which both skeletal and dental problems are corrected as much as possible by OGS. Since our SF belongs to the former style, in terms of Class III, a transitional occlusion usually exhibits an unstable Class II – open bite immediately after OGS. In addition, owing to RAP effects at that time, tooth movement is significantly accelerated and occlusion changes very quickly. Therefore, in the present authors' opinion, the application of fixed appliances with SAS at the beginning of post-surgical orthodontic treatment is advisable. As shown by the present case study, SAS using titanium miniplates was remarkably effective in solving the complex orthodontic challenges presented in the transitional occlusion by the distalisation of the maxillary molars[14-20] and the mesialisation of the mandibular molars. Difficult orthodontic problems can be solved with SAS and fixed appliances in a short period of time, and then the switch can be made to aligner treatment.

While aligners have been more commonly associated with the treatment of mild orthodontic problems such as minor anterior crowding and spaced arch, the current

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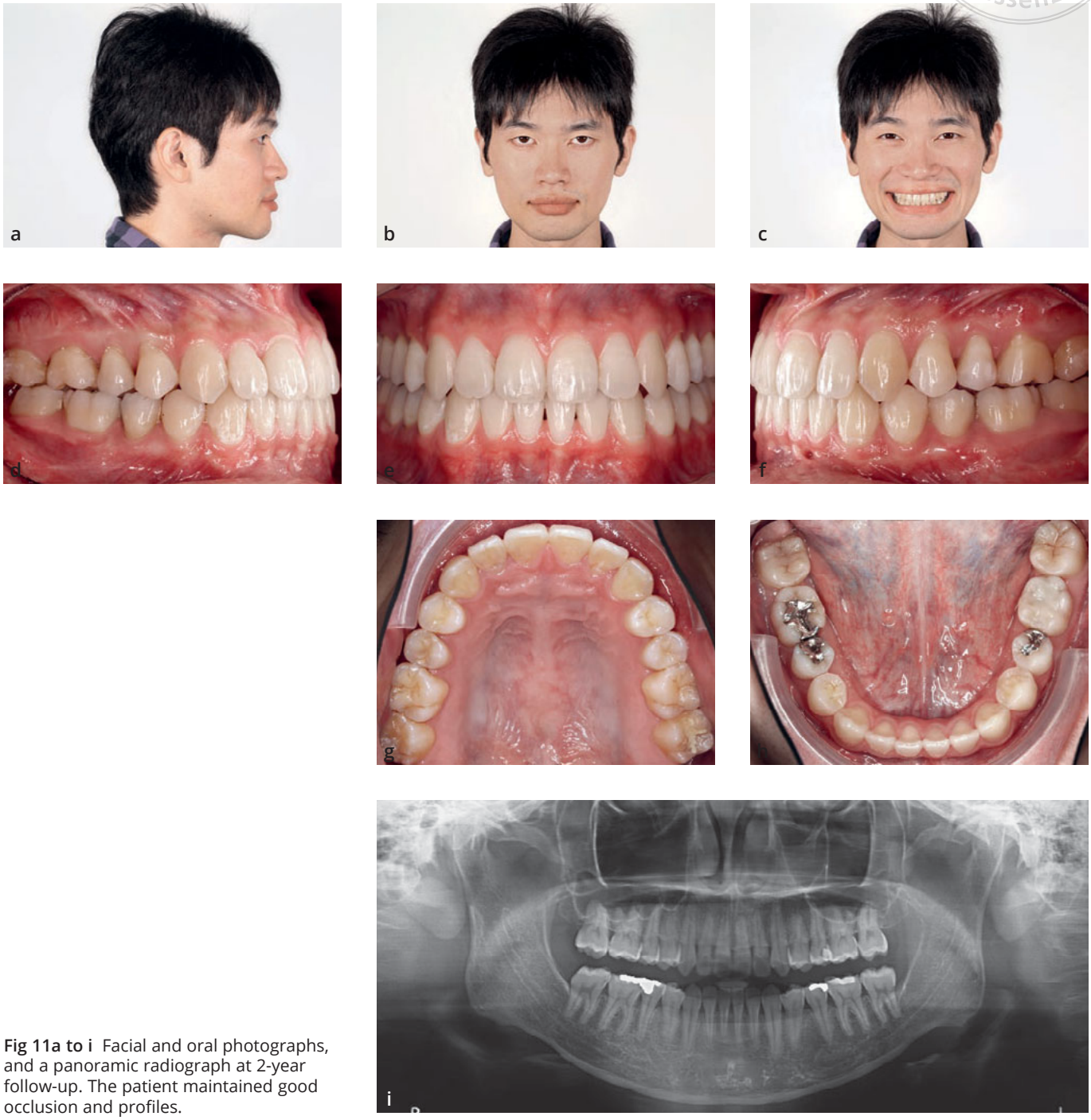

Fig 11a to i Facial and oral photographs, and a panoramic radiograph at 2-year follow-up. The patient maintained good occlusion and profiles.

aligner system is being applied to cases with more complex orthodontic problems such as extraction cases, open bite, interdisciplinary cases and surgery cases. In addition, micro-vibration[21,22] and photobiomodulation[23] are being applied to accelerate tooth movement in combination with aligners. In the present case report, with the added benefit of micro-vibration, the treatment time in post-surgical orthodontics was shortened to 4.7 months following a 4-day change regimen. Note that it was supposed to take 13 months according to a 2-week change regimen. Katchooi et al[22] conducted a randomised trial study on examining the effect of micro-vibration on aligner treatment and concluded that no

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significant effect was found on the reduction of orthodontic pain or oral health-related quality of life, but made no reference to the reduction in treatment time.

The present paper demonstrated a new option for jaw deformity patients to apply SF instead of conventional surgical orthodontics, and aligners for detailing and finishing instead of traditional fixed appliances. The patient was extremely pleased with the short treatment time and the cosmetic and functional outcomes, and showed a significant improvement in his quality of life.

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