Abstract

Traditional extraction therapies in the treatment of dental Class II cases involve either the extraction of upper and lower premolars, or a camouflage type treatment with the extraction of the upper first premolars only. Skeletal Class II correction in growing patients with functional appliances has been well documented. The advancement of the mandible in the treatment and/or prevention of obstructive sleep apnoea has often been prescribed as the treatment of choice. The combination of such therapies in conjunction with the extraction of lower premolar teeth using the Invisalign system is however less prevailing. This paper reports an ideal case selected for such treatment modality and widens the clinician’s perspective on using these appliances.

Keywords: Class II correction, Invisalign extraction, functional appliance

Introduction

The prevalence of Class II dental malocclusions in growing children varies between 33% to 38%, whereas skeletal Class II cases may extend to 70% of the all children of that age group between 6 and 14 years old. Documented treatment modalities of Class II dental malocclusions include extraction or non-extraction therapies with functional appliances (fixed or removable), head gear, the placement of temporary anchorage devices (TADs), dental elastics, and other distalizing devices. Often a combination of any of the above may be required.

Obstructive sleep apnoea (OSA) occurs when a person’s airway becomes partially or completely blocked several times during sleep. The result of this interrupted breathing pattern is severely fragmented sleep. This leads to constant awakening and patients do not get sufficient, good quality sleep, resulting in sleepiness and/or fatigue.

Population-based epidemiologic studies have uncovered the high prevalence of undiagnosed obstructive sleep apnoea, and have consistently
found that even mild obstructive sleep apnoea is associated with significant morbidity. Studies have suggested that the obstructive sleep apnoea may be an important risk factor for stroke\textsuperscript{17} and there has been evidence of genetic predisposition.\textsuperscript{18} One of the common non-surgical approaches for the treatment of obstructive sleep apnoea is a mandibular advancement oral device.\textsuperscript{19} The repositioning of the mandible forwards also allows the tongue to be in a more anterior position, hence preventing it from obstructing the airways.\textsuperscript{20} It is noted that such oral devices are very useful in mild to moderate cases.

The use of a functional appliance to improve the dento-skeletal appearance of growing patients has been previously documented.\textsuperscript{21} However the use of such appliance in a Class I dental malocclusion is less noted. The notion of bringing the mandible forward, into a reverse overjet, and subsequently the extraction of lower premolars to retract the anterior teeth back into an ideal overjet and overbite is daunting as treatment success relies heavily on favourable patient growth, appliance design as well as patient compliance.

Invisalign™ is a series of clear, transparent, custom made polymer-based aligners used to gradually align teeth in stages. Aligners are worn full time between 20 to 22 hours per day and a new set changed every 2 weeks. Since its global launch in 1998, it has gained much popularity.\textsuperscript{22, 23} However many clinicians are still not well versed in its capabilities and have not embarked on using this appliance to treat complex cases. Invisalign Teen® is a newer treatment option with features that allows under-erupted permanent teeth to be incorporated into the system. There is also a blue compliance indicator incorporated into the aligners that reacts with the patient’s salivary enzymes, which denatures the encapsulated protein in the indicator and fades to a lighter blue tinge after the prescribed hours of full-time wear; usually 300 hours within the 2 week period.

A 2-stage treatment was prescribed in this case to allow the improvement of the patient’s dento-skeletal appearance using a stage I functional appliance, followed by full comprehensive orthodontic treatment using the Invisalign Teen® appliance with the extraction of teeth 34 and 44.

This paper reports of a case where the functional appliance was prescribed for reducing the risks of future development of OSA, and effective dento-skeletal changes, followed by full comprehensive orthodontics with extraction therapy using Invisalign Teen®.

**Diagnosis**

A male adolescent, aged 12 years 2 months attended our office with the chief concern of lower dental crowding (Figs. 1-3). Medical history revealed mild episodes nocturnal snoring and the patient’s
mother has been diagnosed of obstructive sleep apnoea (OSA) and is currently on a sleep CAP machine. Although the patient’s recent sleep test did not reveal any hypopnoea, nor reduced oxygen saturation, his parents were still concerned that his retrusive mandible may be a risk for OSA in the future.

He has a mesocephalic ovoid head form, with a convex overall profile with a retrusive mandible. His soft tissue characteristics included a slightly open nasolabial angle, thin lips, and a deep labial mental fold. Skeletally, he had a normal maxilla with a retrusive mandible (Table I). Clinically he has a Skeletal Class II, dental Class I malocclusion with a horizontal direction of growth. There are moderate degrees of lower dental crowding and the lower right second molar appears slightly hypoplastic.

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Initial 17/02/2012</th>
<th>Final 22/04/2014</th>
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</thead>
<tbody>
<tr>
<td>SNA angle (dg)</td>
<td>86.4</td>
<td>86.5</td>
</tr>
<tr>
<td>SNB angle (dg)</td>
<td>79.1</td>
<td>83</td>
</tr>
<tr>
<td>ANB angle (dg)</td>
<td>7.3</td>
<td>3.6</td>
</tr>
<tr>
<td>SN-MP angle (dg)</td>
<td>31.4</td>
<td>25.7</td>
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<tr>
<td>IMPA angle (dg)</td>
<td>108.3</td>
<td>100.3</td>
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<td>FMA angle (dg)</td>
<td>19.5</td>
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</tr>
<tr>
<td>FMIA angle (dg)</td>
<td>54.3</td>
<td>60.2</td>
</tr>
<tr>
<td>Mandibular 1 to APo (mm)</td>
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<td>2</td>
</tr>
<tr>
<td>Maxillary 1 to NA (mm)</td>
<td>2.9</td>
<td>1</td>
</tr>
<tr>
<td>Interincisal angle (dg)</td>
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<td>132.9</td>
</tr>
<tr>
<td>Wits (mm)</td>
<td>2</td>
<td>-1.7</td>
</tr>
</tbody>
</table>

Table I
Treatment alternatives

Several treatment alternatives were presented to the patient and his parents at the consultation appointment. The first option was to commence non-extraction full comprehensive orthodontic treatment with either braces or Invisalign Teen®, re-evaluate after preliminary alignment, followed by the likely extraction of four second premolar teeth. The second option was to commence Stage I functional appliance with twin blocks, followed by the likely extraction of either 2 lower first premolars or a lower incisor, and Stage II braces or Invisalign Teen®.

It was explained to the patient and his parents why a more aesthetic outcome could be expected with the functional appliance treatment therapy. However, they were warned that this treatment plan was not absolute in the prevention of any OSA in the future.

After all the pros and cons for both the treatment options were discussed, it was agreed upon to proceed with the second treatment option. As the patient plays the saxophone regularly, they would prefer a more aesthetic, removable appliance. Functional appliance with twin blocks, followed by Invisalign Teen® was the treatment of choice.

Treatment objectives

The treatment objectives included the advancement of the mandible through functional appliance therapy, improving on his dento-facial profile, correcting the retrusive chin, relieving the lower anterior crowding while maintaining an ideal overjet, and achieving a full unit Class III molar and Class I canine dental relationship.

Treatment plans

Full comprehensive treatment plan involved 2 stages. Stage I was a prescription of full-time wear of Clark Twin Blocks for a period of 6 to 9 months. A transverse expansion screw was incorporated into the upper component of the twin block, there was no lower incisor capping in this design. Once a permanent forward position of the mandible was achieved, selective posterior trimming of the appliance was performed to allow the closure of the posterior open bite. We anticipated the patient to go into a reverse overjet at the completion of the twin block therapy. The molars will be in a Class III dental relationship.

Stage II treatment involved the extraction of teeth 34 and 44 followed by Invisalign Teen® treatment. Class II and/or Class III elastics was required to control anchorage during alignment and space closure.

At the completion of treatment, fixed and removable retainers were designed and prescribed.

Treatment progress

The twin blocks were issued with instructions of full time wear except for eating, brushing and flossing, during swimming and contact sports. The patient was instructed to commence turning transverse expansion screw once every 5 days at the second month into active wear. At the fourth month, a stable prognathic sagittal position was obtained. The posterior bite block of the upper twin block was trimmed down approximately 2 mm to allow closure of the posterior open bite. After 7 months of good compliant wear and positive biological response, completion of stage I treatment was achieved (Fig. 4).
Intra-oral scans (iTero, Cadent) were performed to commence Invisalign Teen® treatment. Teeth 34 and 44 were extracted by his dentist and he suffered a short bout of dry socket; healing was inconsequential thereafter. Due to the ‘bowing’ effect of the aligners during space closure, compensatory dental movements were incorporated into the ClinCheck treatment setup. This included increased mesial root tip of the teeth distal to the extraction sites, and increased distal root tip of the teeth mesial to the extraction sites (Fig. 5).

**Fig. 4** Post functional appliance photographs

**Fig. 5a** ClinCheck Plans showing the reverse overjet after the completion of functional appliance therapy and lower extractions.

**Fig. 5b** ClinCheck Plans showing the attachment designs and compensatory movements.
The sequential aligners were issued uneventfully. There were 34 aligners planned in the first stage of Invisalign Teen® treatment. Attachments prescribed were placed at the seventh week of aligner wear. Positive overjet and overbite was achieved after aligner 23 (Fig. 6), thereafter the patient commenced night time wear of Class II elastics (Chucks ¼” 3.5 oz elastics, 3 M) to maintain anchorage.

As the patient was going away to boarding school for 6 months and would like to have the new refinement aligners arrive before he goes away, intraoral scans were done for an early refinement after aligner 31 (Fig. 7).

The new aligners (total of 11) were issued with new attachment designs (Fig. 8). Triangular posterior elastics were prescribed to improve the posterior occlusion (Chucks ¼” 3.5 oz elastics, 3 M). Treatment completed with the removal of the attachments and buttons. Upper and lower fixed lingual retainer wires were placed. Upper and lower night time removable retainers (Raintree Essix C+) were also prescribed.
Post treatment results completed the occlusion is a full unit Class III molar and Class I canine dental relationship (Figs. 9 -11).

Post treatment results demonstrated that facial aesthetics improved from stage I to stage II and also to completion (Fig. 12). The mandible appeared less retrusive and the patient and parents were pleased with his appearance. The upper and lower dental midlines were coincident with each other and also with the midsagittal plane. The molars were in full unit Class III, the canines in Class I dental relationships with normal overjet and overbite. The final occlusion had good interdigitiation and canine guidance. Root parallelism is satisfactory.

His oral hygiene was well maintained throughout his orthodontic treatment.

Cephalometrically, SNA remained the same while the SNB angle increased from 79.1° to 83.0°, with the ANB angle reduced from 7.3° to 3.6°. The SN-MP angle decreased from 31.4 to 25.7 and the IMPA reduced from 108.3° to 100.3°. The Interincisal angle increased from 116.7° to 132.9°. The absolute maxillary length increased from 91.6mm to 100.8 mm while the mandibular length increased from 108.7 mm to 125.7 mm (Table I).

The overall superimposition on SN demonstrated that the patient grew favourably downwards and forwards throughout treatment (Fig. 13). The Y axis and upper and lower facial heights remained relatively

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**Fig. 10** Post treatment cephalometric radiograph

**Fig. 11** Post treatment panoramic radiograph

**Fig. 12** Profile changes

**Fig. 13** Regional and overall superimpositions
unchanged, however the SN-MP angle reduced rather significantly from 31.4° to 25.7°. This anti-clockwise rotation of the mandible made the patient’s mandible less retractive, decreases the depth of the labial mental fold and the eversion of the lower lip.

The upper and lower lips came forwards with the lower lip increasing almost double the distance of the upper lip. This extent of increase was replicated in the increase of the maxilla and mandibular length as well.

Maxillary regional superimposition showed restriction of dental movements and remained stable. The upper molar erupted from the maxillary plane likely due to the anti-clockwise rotation of the mandible and posterior elastic wear during the Invisalign Teen® treatment. Mandibular regional superimposition showed a retraction of the lower incisors as crowding was relieved backwards; the IMPA reduced from 108.3° to 100.3°. The molars also protracted forwards and extruded slightly. The extrusion of the lower molars was likely due to the over-eruption at the end of the twin block treatment when the upper posterior bite blocks were trimmed down. This further encouraged the increase of the lower facial height.

The post-treatment radiographs showed no evidence of root resorption or any other pathology. The third molars are present and still unerupted. We discussed further with his dentist and parents about the prognosis of the hypoplastic lower right 2nd molar and suggestions included its removal to allow the lower right 3rd molar to erupt into its position.

Upper and lower fixed lingual retainers were placed with the patient also wearing night time removable vacuum formed retainers as well.

Active functional appliance treatment was 7 months. Active treatment with Invisalign Teen® was 17 months. Total active orthodontic treatment was 24 months.

Discussion

The patient commenced treatment at 12 years and 2 months old. Based on the cervical vertebrae maturation index, the C3 and C4 of the lateral cephalogram demonstrated skeletal maturity of CS3. This indicated that the patient was going to hit his growth spurt rather immediately.24 The commencement of functional treatment with twin blocks requires the favourable growth of the child and timing of treatment is paramount.

Routine functional appliance therapy could range between 6-12 months. The success of treatment is rather multifactorial. It relies heavily on the timing of the treatment (in concurrent with the patient’s growth spurt), appliance design, favourable growth direction, and patient compliance. Although there was no imminent posterior crossbites, the patient was instructed to commence turning transverse expansion screw once every 5 days after the second month into active wear. As the mandible comes forwards, the transverse discrepancy between the upper and the lower arch form will become eminent. The final planned occlusion is a full unit Class III molar and a Class I canine dental relationship. Therefore although there was no evident posterior crossbite initially, it was essential to have the upper and lower arch forms articulate into a correct transverse relationship bearing the final occlusion in mind.

At the fourth month, a stable prognathic sagittal position was obtained. This was confirmed by relaxing
the patient’s mandible and guiding its condyles back into their most posterior, superior position. A postured prognathic mandibular position is due to muscular adaptation and is not a stable, reproducible position, often leading to a ‘false positive’ correction. It is essential to have the corrected position maintained for a few months, and allow the settling of the occlusion, obtain a good interdigitation to maintain the corrected mandibular position. The result was achieved with judicious trimming of the bite plane of the upper component of the twin blocks to allow the closure of the posterior open bite often seen at the completion of sagittal correction in functional appliance therapy. The twin block appliance was worn with excellent compliance and stage I treatment was completed in 7 months.

The treatment prescribed in this paper is not unlike the ‘surgical first’ technique. The ‘surgery first’ technique in combined orthodontic-orthognathic surgery cases was first described in 2009. The premise of this technique was to perform the jaw movements via surgery prior to the orthodontic treatment phase. The alignment, space closure and decompensation movements were all performed after the surgical procedure. It has been noted in these cases that the efficiency of treatment improved. The correction of the skeletal imbalance was first achieved, the complexity of the treatment decreases with the elimination of soft tissue imbalances that might hinder treatment.

Using functional appliance therapy to correct the skeletal discrepancy, eliminating any soft tissue imbalances may pave the way to more efficient orthodontic treatment. The ability to achieve a stable mandibular position post twin block treatment gives us the assurance that extraction on the lower jaw only in a skeletal Class II case will complete the case in an ideal overjet and overbite. The increase in vertical dimensions through the patient’s growth and functional therapy has also allowed the bite opening to occur, thus further enhancing the efficiency of the orthodontic treatment.

The ANB angle reduced quite remarkably during treatment underlying the effects of the functional appliance therapy. The optimal timing of treatment and favourable vertical growth of the patient also allowed the enhancement of his natural downward and forwards growth of both the maxilla and the mandible. The forward rotation of the mandible during treatment is observed with the decrease in the SN-MP angle. The IMPA reduced despite the relieving of the lower dental crowding as the lower $1^{st}$ premolar teeth were extracted.

Mandibular advancement splints traditionally used to treat OSA in adult patients increases the pharyngeal airway space and prevents the physical blockage. However there have also been frequent reports of permanent dental changes of the occlusion after long term use. Enhancing the effects of a functional appliance such as a twin block in a growing child, we have capitalised on this side-effect in this particular case. The permanent advancement of the mandible in this case has ensured patency of the airways in the prevention of the OSA as set off from the beginning in our treatment objectives.

Full comprehensive orthodontic treatment with Invisalign has been previously criticized. Its inability to control bodily movements, especially so in extraction cases, have made it an inferior treatment of choice. However with careful understanding and thorough planning, superior results can be obtained. As Invisalign
is removable appliance, the degree of ‘play’ between the appliance and the dentition dictates the true tracking of the appliance. Compensatory movements need to be planned within the ClinCheck set up to allow these intended movements to occur (Fig. 5b). In this extraction case, the teeth distal to the extraction sites had 8 degrees more mesial root tip placed on them. The lower canines (tooth immediately mesial to the extraction site) had 8 degrees more distal root tip placed on them.

During the lower space closure, the lower curve of Spee inevitably deepened. Compensatory movements with the further intrusion of the lower incisors during the first ClinCheck set up should have been planned. This has resulted in an anterior interference and posterior open bite at the end of the first lot of aligners. During the refinement stage, posterior triangular box elastics had to be worn to allow the occlusion to settle into a normalised bite. The recent launch of Invisalign G6 has made attempt to counter this said effect for extraction cases with modified staging patterns as well as new optimised attachment designs.

Conclusions

Effective and efficient treatment was rendered for this growing patient using an alternative treatment technique with a great treatment outcome.

A growing child with a family history of OSA, skeletal Class II pattern but with a Class I dental occlusion required orthodontic treatment. The mandibular advancement with the twin block functional appliance brought his lower jaw forwards, improving his dento facial profile. His optimal growth pattern allowed the improvement of his vertical facial ratios. With the correction of his Class II skeletal pattern, we also maintained a patent pharyngeal airway in order to reduce the chances of developing OSA in the future.

The reverse overjet was corrected by the extraction of 2 lower 1st premolar teeth. This effectively corrected the lower dental crowding while maintaining a good lower incisor angulation with the mandibular plane as well as its position in space. A therapeutic Class III dental occlusion with a full unit Class III molar and Class I canine relationship achieved was stable and functional.

The upper and lower fixed retainers were also prescribed with night time removable vacuum formed retainers to maintain treatment stability. The patient will be monitored periodically post-treatment for repairs, relapse and erupting wisdom teeth. The patient was referred back to his regular dentist for routine checks.

References


