Surgical Alteration of Occlusal Plane Angulation Followed by Orthodontic Application of TADs and Yin-Yang Arch Wire in Hypodivergent Prognathic Malocclusion

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This case report presents a skeletal deformity which primarily resulted from excessive transverse growth and reduced vertical growth in the midface and upper dentition. The counterclockwise growth rotation and excessive forward growth mandible aggravated the sagittal jaw bone discrepancy. The dental effect included canted maxillary occlusal plane and severe attrition of the upper teeth. By the combined treatment with orthognathic surgery and orthodontics, the patient with extreme low mandibular plane angle could be well treated to proper facial proportion and harmonization.

Keywords
Vertical maxillary deficiency; Hypodivergent and prognathic mandible; Clockwise rotation of the maxillo-mandibular complex (MMC); Occlusal plane canting

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Dental Department, Taipei Medical University, Taiwan

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INTRODUCTION

Rotation of maxillo-mandibular complex (MMC) in 2-jaw orthognathic surgery (OGS) could flexibly change the jaw bone relationship by more forward and backward movement in the mandible as compare to a straight forward and backward surgical movement. MMC refers to a triangle enclosed by three anatomical landmarks including anterior nasal spine (ANS), posterior nasal spine (PNS) and pogonion (Pog) in lateral cephalometric tracings. This triangular area covered part of 2 jaw bones and both upper and lower dentitions. The tooth bearing parts of the maxilla and the mandible can be mobilized as a whole, that is, the MMC would be rotated surgically in either clockwise or counterclockwise direction and at different centers of rotation as needed. The measurements consequently could be changed in the steepness of the palatal plane and occlusal plane, the position of the pogonion and chin, as well as the upper and lower incisor angulations. Once those skeletal flaws were corrected surgically and with orthodontic efforts, complete improvement of dental occlusion, oral function and soft tissue esthetics could then be accomplished.

CASE REPORT

Clinical examination

A 32-year-old Taiwanese female had a broad and short facial pattern and was not satisfied with the aging appearance in her front teeth. Less upper
incisor show, short crown height of upper incisors from severe attrition and upper occlusal plane canting were found (Figures 1–3). Prominent chin and long chin-throat length were also noted on her lateral profile (Figure 4).

Clinical evaluations indicated very low angularizations of both occlusal and mandibular planes (Table 1) and led to an impression of vertical maxillary deficiency (VMD) combined with prognathic but hypodivergent mandible, and canting of the occlusal plane. Due to the severity of skeletal dysplasia, orthodontic mechanotherapy was quite insufficient for this case and demanded OGS intervention. Favorable changes could be reached after normalization of the angularizations of both occlusal and mandibular planes by surgeons, the orthodontists then became capable of completing the correction of the relevant dentofacial problems.

The patient had a concave facial profile with protruded chin. Slightly increased lower anterior facial height (LAFH) was noted in the facial proportion to reflect the insufficiency of mid facial height. The proportion of the nose to upper lip and lower lip to the chin was normal. Disharmonic smile arc and diminution of the incisor show at right side were noted (Figure 1).

Intraoral examinations discovered distinct upper reversed compensatory tooth curvature, spacing and generalized tooth attrition. Upper and lower dental midlines did not coincide, the lower one was deviated to her right side. The right-side-up occlusal plane canting was clearly seen from the front view. The posterior teeth in both dental arches were all mesially inclined and lingually tilted (Figure 2).

Canine and molar relationships were Class II at the right side and Class I at the left. The overjet was normal, and the overbite was 3.5 mm. The tooth size in mesio-distal dimension measuring from the dental study casts was found to be smaller than normal in both dental arches. The anterior Bolton's
Figure 3. Study casts showed that both canine and molar relationships were Class II at right side and Class I at left. The curve of Spee was measured on the lower arch as 2 mm which was not deep. The overjet was 2 mm and overbite was 3.5 mm.

Figure 4. Pre-treatment radiographs. (a) The chin-throat length was 50 mm. (b) The facial index (facial height/bizygomatic width) was 82% and classified as euryprosopic facial pattern. (c) The periodontal condition was acceptable.
ratio was 82%, indicating the relatively larger size of lower anterior teeth when compared to upper anterior teeth (Figure 3).

The facial index was measured from the facial height (nasion to gnathion) divided by the bizygomatic width (right zygomatic arch, ZA, to left zygomatic arch, AZ) and then multiplied by 100. The facial index (82%) of the present case was classified as "euryprosopic face", which was defined ranging from 80 to 84.9%. Mandibular deviation was confirmed from posteroanterior (PA) cephalometry, the menton point shifted to her right side about 3 mm. Her four 3rd molars were absent. The TMJ condition was found normal without pathological resorption at the condylar head (Figure 4).

Table 1. Cephalometric analysis.

<table>
<thead>
<tr>
<th></th>
<th>Norm</th>
<th>Initial</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>SN-FH</td>
<td>5.5</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>SNA</td>
<td>82.9</td>
<td>87</td>
<td>89</td>
</tr>
<tr>
<td>SNB</td>
<td>80.8</td>
<td>87.5</td>
<td>84.5</td>
</tr>
<tr>
<td>ANB</td>
<td>2.1</td>
<td>-0.5</td>
<td>4.5</td>
</tr>
<tr>
<td>A-NVert(mm)</td>
<td>-1.8</td>
<td>7.5</td>
<td>8.5</td>
</tr>
<tr>
<td>Pog-NVert(mm)</td>
<td>-6.6</td>
<td>12.5</td>
<td>7</td>
</tr>
</tbody>
</table>

**Skeletal relationships (A–P)**

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>PFH/AFH ratio</td>
<td>0.66</td>
<td>0.70</td>
</tr>
<tr>
<td>UAFH/LAFH ratio</td>
<td>0.82</td>
<td>0.87</td>
</tr>
<tr>
<td>LAFH</td>
<td>71.4</td>
<td>63</td>
</tr>
<tr>
<td>Y-axis</td>
<td>68.5</td>
<td>62</td>
</tr>
<tr>
<td>SN-MP</td>
<td>30.9</td>
<td>25</td>
</tr>
<tr>
<td>PP-MP</td>
<td>21.6</td>
<td>12.5</td>
</tr>
<tr>
<td>FH-OP(occlusal plane angle)</td>
<td>8.0</td>
<td>9</td>
</tr>
<tr>
<td>Upper gonial angle</td>
<td>47.6</td>
<td>31</td>
</tr>
<tr>
<td>Lower gonial angle</td>
<td>72.6</td>
<td>64.5</td>
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</table>

**Dentition (A-P)**

<table>
<thead>
<tr>
<th></th>
<th>Initial</th>
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<tbody>
<tr>
<td>U1-SN</td>
<td>106.3</td>
<td>99.5</td>
</tr>
<tr>
<td>U1-NA</td>
<td>23.5</td>
<td>9</td>
</tr>
<tr>
<td>U1-NA(mm)</td>
<td>5.3</td>
<td>0</td>
</tr>
<tr>
<td>L1-MP</td>
<td>94.1</td>
<td>107</td>
</tr>
<tr>
<td>L1-Apog(mm)</td>
<td>4.4</td>
<td>4</td>
</tr>
<tr>
<td>L1-NB</td>
<td>25.9</td>
<td>36</td>
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<tr>
<td>L1-NB(mm)</td>
<td>6.1</td>
<td>3</td>
</tr>
<tr>
<td>U1-L1</td>
<td>128.6</td>
<td>126.5</td>
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**Dentition (Vertical)**

<table>
<thead>
<tr>
<th></th>
<th>Initial</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1-PP</td>
<td>30.2</td>
<td>26</td>
</tr>
<tr>
<td>U6-PP</td>
<td>25.6</td>
<td>R/23.5/L:25 R/24.5/L:25.5</td>
</tr>
<tr>
<td>L1-MP</td>
<td>40.2</td>
<td>33</td>
</tr>
<tr>
<td>L6-MP</td>
<td>32.4</td>
<td>R/31.5/L:29.5 R/33/L:31</td>
</tr>
</tbody>
</table>

**Soft tissue profile**

<table>
<thead>
<tr>
<th></th>
<th>Initial</th>
<th>Final</th>
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<tbody>
<tr>
<td>NLA</td>
<td>90.5</td>
<td>93</td>
</tr>
<tr>
<td>Upper lip -E line(mm)</td>
<td>1.9</td>
<td>-3.5</td>
</tr>
<tr>
<td>Lower lip -E line(mm)</td>
<td>1.8</td>
<td>-1.5</td>
</tr>
</tbody>
</table>

The cephalometric analyses were presented in Table 1. Compared to the norm, the decreased values of LAFH and SN-MP angles were further confirmed. The near parallelism of the palatal plane, occlusal plane, mandibular plane and Frankfort horizontal (FH) plane was also found. The performance of those horizontal planes represented the existence of severe vertical handicaps in the dentition, and it was difficult for orthodontic bite opening as pointed out by Schudy.4

The lower gonial angle was smaller than the norm. The mandible was grown in a hypodivergent pattern. The U1-SN and L1-MP were found in normal range, the decreased U1-PP value indicated under-eruption of upper incisors.

**Diagnosis**

With findings of prominent chin, small mandibular plane angle, less LAFH, insufficient upper incisor display, severe upper incisor attrition and decreased occlusal plane angle etc., the diagnosis of this case were listed as: (1) vertical maxillary deficiency; (2) skeletal deep bite resulted from both vertical
maxillary deficiency and hypodivergent growth of the mandible; (3) upper occlusal plane canting caused by combination of skeletal factors mentioned above; and (4) moderate deviation of the mandible.

Treatment objective

The treatment objectives are: (1) to correct the occlusal cant and the mandible deviation with surgical correction; (2) to improve the facial profile and proportion; (3) to obtain acceptable upper incisor display and better smile arc; (4) to restore optimal overjet and overbite; (5) to achieve stable occlusion with Class I canine and molar relationships.

Treatment plan

Non-extraction orthodontic therapy with leveling and alignment of the dentitions by arch wires, and arch coordination would be finished only transversely, but left the upper occlusal plane canting remained untreated or even became more tilted in the presurgical stage. The MMC will then be clockwisely rotated in sagittal (pitch) direction and roll rotation to correct the occlusal plane cant. The mandibuloplasty would be carried out to reshape the gonial angle. Combination of one temporary anchorage device (TAD) and left-side auxiliary intrusive lever arm on the upper arch, and Yin-Yang arch wire at lower dentition would be used.

Full mouth bonding was performed with fixed pre-adjusted appliances of .022-inch x .028-inch OPA-K brackets. Leveling of teeth using .014-inch NiTi arch wire was started. Posterior bite turbos were added to bilateral first molars for dental disocclusion.

Presurgical orthodontic treatment was prepared to gain transverse coordination of both dental arches and to diminish the occlusal interferences. The arch wires were changed to .017 x .025 inches stainless steel wires in the upper arch and .016 x .022 inches stainless steel wires in the lower arch while proceeding to surgery (Figures 5 and 6). LeFort I one-piece osteotomy in the maxilla and bilateral sagittal split osteotomy (BSSO) in the mandible were adapted and clockwise pitch rotation in both jaws was executed. The rotation center of the MMC was located higher than upper incisor tip to increase upper incisor display and decrease chin projection concomitantly. At the frontal aspect, MMC roll rotation was performed to partially correct the occlusal cant, to center the chin, and to adjust lower dental midline to the facial midline (Figure 7).

Bilateral mandibuloplasty at the gonial region was carried out to soften the bony ledge after clockwise rotation of the MMC. Rigid fixation in the maxilla and the mandible for better stability was necessary. However, interocclusal splinting or postoperative maxillomandibular fixation was not used in this case. After surgery, mild occlusal plane canting and lower midline deviation still present and the treatment moved to post-surgical orthodontics (Figures 8–10). An infrrazygomatic crest (IZC) TAD was inserted at the upper left side. Unilateral auxiliary intrusive lever arm was used to intrude upper left anterior teeth. This force, however, will also produce an unwanted extrusive effect and should be canceled by tying molars to the TAD. In the lower dentition, a single, continuous Yin-Yang arch wire and asymmetrically use of short elastics would be good enough to correspond the effect of leveling the canting (Figure 11). Space closure and midline adjustment were followed. After detailing and space consolidation, the full mouth fixed appliances were removed, and removable Hawley retainers were delivered.

The patient had postponed many appointments during the treatment, the total therapy ended after 35 months, which was longer than expected.
The facial appearance of the patient was improved. From the frontal view, the chin point was coordinated with the facial midline, and a smoother mandibular contour was noted (Figure 12). The upper and lower dental midlines were coincided, and the occlusal plane canting was almost corrected (Figure 13).

From the lateral cephalogram, decreased chin projection was noted. Panoramic radiographs showed good roots parallelism (Figure 14). The cephalometric analyzing data indicated effective skeletal and dental correction (Table 1). ANB angle increased from $-0.5^\circ$ to $4.5^\circ$; LAFH increased from 63 to 65 mm; and the occlusal plane angle (FH-OP) was changed from $2^\circ$ to $9^\circ$. The labial inclination relative to the S–N plane of upper incisors changed...
from 109.5° to 99.5° and that of the lower incisors were from 97° to 107°.

The superimpositions of pre-and post-treatment cephalometric radiographs showed that anterior down-posterior up rotation of the maxilla and backward rotation of the mandible were achieved after MMC clockwise pitch rotation. Extrusion of upper incisors, intrusion of upper molars, lower incisors increased their labial inclination and lower molars extrusion were achievement of dental improvements (Figure 15).

The profile and facial proportional changes were noted (Figure 16). The upper incisor display increased significantly (Figure 17). The follow up records revealed stable treatment results (Figure 18).

Figure 9. The chin position moved downward and backward as shown with the yellow arrow. The vertical dimension was therefore increased.

Figure 10. Lateral, frontal cephalograms and panoramic radiographs were taken two weeks after surgery.

Figure 11. An auxiliary intrusive lever arm, made of .016 × .022 inches titanium-molybdenum alloy (TMA) wire for anterior intrusion was installed over upper left side (yellow dotted circle) to correct residual upper occlusal plane canting by orthodontic mechanotherapy after surgery. With ligature wire, the upper left first molar was tied to TAD (black circle) at the left infrazygomatic crest region to prevent molar extrusion caused by the lever arm. Instead, on the lower arch, a continuous Yin-Yang arch wire made of .017 × .025 inches TMA was used to correct occlusal cant at the same time (yellow arrow). The dental midline of both arches was almost coincident.
Most patients accept OGS for the purpose of not only to treat dentofacial deformities but also to improve esthetic appearance, attractiveness and self-confidence. However, in some cases, the esthetic outcome fails to be accomplished by jaw movement in the anteroposterior (AP) or vertical direction. Instead, in the present case, the skeletal dysplasia and canting of the occlusal plane were feasibly treated by surgical intervention of the rotation in the MMC.

In fact, MMC is the skeletal part of the lower face. The size, shape and position of MMC therefore play a major role in soft tissue esthetics of the lower face.

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**DISCUSSION**

The soft tissue profile was remarkably changed with increasing upper lip support and reduction of chin projection. The occlusal plane canting had almost disappeared. The enhancement of the upper incisor display was satisfactory. The consonant smile arc and other esthetic improvement were achieved with effective occlusal plane alteration at finishing.

![Figure 12](image)

Figure 12. The soft tissue profile was remarkably changed with increasing upper lip support and reduction of chin projection. The occlusal plane canting had almost disappeared. The enhancement of the upper incisor display was satisfactory. The consonant smile arc and other esthetic improvement were achieved with effective occlusal plane alteration at finishing.

All spaces were closed. In post-treatment records, optimal overbite, overjet, and good interdigitation of the dentition were obtained. The lingual tilted lower posterior teeth were corrected. The upper anterior gingival line became harmonious.

![Figure 13](image)

Figure 13. All spaces were closed. In post-treatment records, optimal overbite, overjet, and good interdigitation of the dentition were obtained. The lingual tilted lower posterior teeth were corrected. The upper anterior gingival line became harmonious.

The chin-throat length was changed from 50 to 46 mm after treatment. Root parallelism was acceptable as shown in panoramic radiograph.

![Figure 14](image)

Figure 14. The chin-throat length was changed from 50 to 46 mm after treatment. Root parallelism was acceptable as shown in panoramic radiograph.
MMC rotation technique was necessary in altering the occlusal plane and changing the axis of the incisors. The occlusal plane angulation is important for esthetic evaluation but often neglected. Normal occlusal plane angle (FH-OP) was around 8°, the deviation of this plane may reflect by the different

Figure 15. Superimposed tracings of pre-treatment and post-treatment lateral cephalograms.

Figure 16. Profile and facial proportional changes were noted.

Figure 17. Change of upper incisor display and smile arc before and after treatment was demonstrated.
Clinically, the abnormalities such as anterior deep bite, low mandibular plane angle, prominent chin relative to the mandibular alveolus, accentuated curve of Spee in the lower arch, and sometimes a reversed compensating curve in the upper arch are observed frequently in patients with decreased occlusal plane angle lower than 4°.5–11

Patient’s squared facial appearance resulted from hypodivergent mandible and low occlusal plane angle. Clockwise pitch rotation of the MMC is decisive and mandatory in normalizing both occlusal and mandibular plane angles and lower anterior facial height. It was also enough to make the face looks slenderer, because the mandible was rotated downward and backward.5

In the event of performing the mandibuloplasty alone, it may not have esthetic outcomes on facial width because the lower anterior facial height did not change. In addition, excessive mandibular angle reduction may end up with unnatural, more sagging and depression of the soft tissue.5 With the clockwise pitch rotation of the MMC, the amount of bone resection of bilateral mandibular gonial angles

![Figure 18. The photographs were taken three months after debond. No noticeable relapse was found.](image)

![Figure 19. (a) Two MMC changes after surgical rotation with higher or lower positions of center of rotation were both illustrated. The higher position was drawn in red, and the lower position was in blue. (b) Pre-treatment MMC was drawn in black, and the post-treatment was in red. The higher point of rotation was selected in this case.](image)
could be reduced to achieve better treatment results. In case like this patient sought a more esthetic outcome, more gonial angle reduction might be considered.

To determine the vertical position of the maxilla, the tooth crown length, gingival display and the smile arc at rest or during posed smile were factors deserving considerations. Insufficient incisor display and flat smile arc were prone to show aging, which was the part of the patient's main concern. The MMC clockwise pitch rotation can increase the incisor show and make the smile arc consonant to the lower lip. The choice of location of the rotation center during surgery also plays an important role in esthetic change of the soft tissues. As shown in both Figure 19 and Table 2, if the center of the rotation of the MMC was higher than the upper incisor tip, the paranasal soft tissue and upper lip support will be less affected or decreased, the more reduction of the chin projection will occur, and the upper lip support will be much enhanced when the center of rotation was set lower. Because the patient had increased SNA and decreased nasolabial angles, the need for increasing the upper lip support became less and the higher center of rotation was more suitable than lower position (Figure 19b).

The clockwise rotation of the MMC was recommended as a relatively stable surgical measure since the length of the masticatory muscles was shortened instead of stretched as in other surgical methods. The reduction of the volume of the masticatory muscles by the mandibuloplasty might be favorable to the decrease of strong biting force adherent in this patient's oral musculatures. For the treatment of low angle malocclusion, MMC clockwise rotation can open the bite effectively; decrease the chin projection and shortened chin throat length (Figures 4 and 14). There are few risks worth noticing, posterior displacement of the tongue or airway narrowing might occur. Patients with sleep apnea should avoid this surgical modality. In brief, the surgical scenario is as follows: LeFort I surgery can be managed to make the occlusal plane tilted with the fulcrum higher than upper incisor tip (Table 2). As the occlusal plane is increased within a range between 0 and 8 degrees in

<table>
<thead>
<tr>
<th>Soft tissue changes</th>
<th>Location of the center of rotation</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Higher position (Higher than upper incisor tip)</td>
</tr>
<tr>
<td>Paranasal soft tissues</td>
<td>Less affected</td>
</tr>
<tr>
<td>Upper lip support</td>
<td>Less affected or decreased</td>
</tr>
<tr>
<td>Chin projection</td>
<td>Greatly decreased</td>
</tr>
<tr>
<td>Cervicomental soft tissues</td>
<td>Greatly decreased chin throat length</td>
</tr>
<tr>
<td></td>
<td>Lower position (Lower than upper incisor tip)</td>
</tr>
<tr>
<td></td>
<td>Increased paranasal fullness and advance subnasal area</td>
</tr>
<tr>
<td></td>
<td>Increased</td>
</tr>
<tr>
<td></td>
<td>Decreased</td>
</tr>
<tr>
<td></td>
<td>Decreases chin throat length</td>
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Figure 20. Pre- and post-treatment frontal cephalometric tracings were compared. Midsagittal reference line (MSR) was constructed from crista galli (CG) through the anterior nasal spine and further extends to the chin. ZA and AZ are the most lateral aspects of the zygomatic arches. FOP, standing for frontal occlusal plane, represented the line connecting the midpoint of the occlusal surface of the upper first molars in both sides.
general, the piriform rim area will advance forward, and the upper molars will move superiorly. Since the MMC rotated as a piece, the mandible will become rotated along the new occlusal plane, and the chin will rotate posteriorly. It was the depth of the palatal bone, the sagittal and vertical position of upper and lower incisors as well as other surrounding anatomical structures that determined and set the limitations to the extent of such rotation.

The frontal cephalogram tracings before and after treatment were compared (Figure 20). Unequal distance of total mandibular length (CoR-ME and CoL-ME) and the mandibular ramal height (CoR-AG and CoL-GA) between right and left sides have shown discernible improvement after treatment. The values of these measurements were finally closed to even on both sides. The intersection angle between ZA-AZ line and the frontal occlusal plane (FOP) indicated that the correction of the occlusal plane canting was also achieved (Table 3). The angle decreased from 5° to 2° after treatment. The mechanics of auxiliary intrusive lever arm had been reported. It improved the anterior occlusal cant but also had the side effect of worsening the posterior occlusal cant due to the reaction force applied on the posterior teeth. Therefore, in this case the TAD was used to provide a direct anchorage to prevent extrusion of the upper left posteriors, whereas the Yin-Yang arch wire at the lower arch can provide intrusion for the right posteriors and extrusion of the left posteriors. The left-side-down occlusal cant was corrected by using a continuous lower Yin-Yang arch wire with a right-side-down and left-side-up orientation at the frontal view. The force was delivered in equal and reciprocal intrusion and extrusion between right and left sides (Figure 11). In the present case, the occlusal refinement to have normal relation of both jaws and dentitions was smoothly accomplished. Moreover, increased incisor display and stable occlusion could result in harmonious smile and healthy soft tissues. In the collaboration between orthodontics and craniofacial surgery, those treatment goals can be successfully achieved (Figures 12–17).

CONCLUSION

Surgical-orthodontic combination treatment in this case was demonstrated to be effective in changes of the entangling malocclusions including canted occlusal plane, severe deep bite, extremely small mandibular plane angle, related dental attrition and unsatisfactory facial appearance all together.

The strategies involved surgical clockwise rotation of MMC to open the bite and rotate the occlusal plane in downward and backward direction. The roll rotation of MMC also improved the canted occlusal plane. The post-surgical orthodontics was further managed with TADs for unilateral molar intrusion and a continuous Yin-Yang arch wire for lower occlusal plane correction. All the main treatment goals were achieved.

ETHICAL APPROVAL

None.

PATIENT CONSENT

Provided.

Conflict of Interest Statement

The authors declare no conflicts of interest.

REFERENCES


