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Original Article

Evaluation of Maxillary Protraction Using a Mini Screw-Retained Palatal C-Shaped Plate and Face Mask

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Main Points

- The use of a palatal plate face mask provides a minimally invasive skeletal approach that is comfortable for both the patient and operator.
- Maximum skeletal changes with minimum dentoalveolar changes can be obtained from palatal plate face mask combination.
- Combination of the palatal plate and face masks provides an excellent treatment alternative, particularly in patients with insufficient dental support.

ABSTRACT

Objective: To evaluate a newly designed minimally invasive palatal-plate face mask combination for the management of developing Class III malocclusion due to maxillary deficiency.

Methods: A sample of 16 Class III patients due to maxillary deficiency in the early mixed dentition (8 boys and 8 girls) aged between 7 and 9 years participated in this study and were treated with a combination of palatal plate face masks. Extra-oral elastics were attached between the intra-oral and extra-oral appliances; the elastics were set at 30° to the occlusal plane. The force magnitude was 250-300 g per quadrant. Cephalometric radiographs were taken before and immediately after maxillary protraction. In addition, skeletal measurements were measured, tabulated, and statistically analyzed. The pre- and post-protraction measurements were compared using the Student's t-test, and the significance level was set at a p-value <0.05.

Results: A statistically significant increase in SNA angle and maxillary length was observed by 3.13±1.52 degrees and 2.60±0.75 mm (p<0.05), respectively, indicating forward maxillary growth. The skeletal and soft tissue patterns were also improved, as evidenced by the statistically significant increase in the ANB angle, Wits appraisal, and H angle by 4.50±1.28 degrees, 5.30±1.86 mm, and 5.02±3.24 degrees (p<0.05), respectively. A favorable clockwise mandibular rotation was observed as evidenced by the increase in the SN/MP angle and the decrease in the SNB angle by 1.46±1.96 degrees and -1.38±1.86 degrees (p<0.05), respectively.

Conclusion: The palatal-plate facemask combination is an effective treatment alternative for Class III malocclusion due to maxillary deficiency with minimal pain and discomfort.

Keywords: Class III treatment, face mask, palatal anchorage, palatal plate, skeletal anchorage

INTRODUCTION

Maxillary protraction using a face mask is one of the most common alternatives for managing Class III malocclusion caused by maxillary growth impairment. Face mask therapy with dental anchorage is the most common approach for maxillary protraction. This approach can protract the maxilla by correcting the skeletal and soft tissue profiles. However, most of these changes were dental rather than skeletal, such as protrusion of the maxillary incisors, extrusion and mesial tipping of the maxillary molars with subsequent clockwise mandibular rotation, and elongation of the face.[1]

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Several studies[2-4] have evaluated surgical miniplates and miniscrews for providing skeletal anchorage for maxillary protraction in midface deficiency. Different techniques were described, varying according to the surgical miniplate placement site, force magnitude, and use of adjunctive intraoral or extraoral appliances. These techniques provided a treatment option for patients with a skeletal deformity that was judged too severe to be treated by dentoalveolar compensation alone, and the degree of maxillary hypoplasia and age were not favorable for facemask therapy. However, this technique is aggressive, as additional surgery to remove the miniplate is necessary with potential damage to the developing dental buds. Furthermore, injury to vital structures, such as the maxillary sinus, is a risk factor.[2,5]

Several studies[6,7] have evaluated the suitability of the palate as a skeletal anchorage site in the mixed dentition period and found that the palatal bone was suitable for TADS insertion in growing patients. In addition, the palatal area was used to support skeletally anchored intraoral distalization appliances without any surgical intervention using a minimally invasive approach.[8]

No previous clinical studies have evaluated palatal miniplate-anchored face mask therapy. Therefore, this study aimed to assess the dental and skeletal effects of a modified C- shaped miniplate fixed to the palate as a means of traction of the maxilla in combination with a face mask in growing Class III patients with maxillary deficiency.

METHODS

Sample Size Calculation

The sample size calculation was based on data obtained from a pilot study on four patients. The first outcome selected was a change in the SNA angle. The mean difference was 1.5 degrees, with a standard deviation of 1.45, a confidence level of 95%, and a power of 80%. The sample size calculation was performed using an online sample size calculator (Sample Size Calculator Version 1.058). The sample size calculated was 16.

The data used were a T1 mean of 77.14, a T2 mean of 80.27, a standard deviation of 1.52, an alpha two-sided value of 0.05, and a sample size per group of 16. The power of the study was 0.9999.

The Sample

The study sample comprised 16 patients (8 boys and 8 girls). The researcher explained the purpose of the study and treatment procedures to all patients. Furthermore, written informed consent was obtained from all participants, in accordance with the guidelines for human research adopted by the Research Ethics Committee. The Tanta University Faculty of Dentistry Research Ethics Committee approved the study protocol (approval no.: #R-ORTH-11-17-1, date: April 2022).

The participant patients were selected based on the following criteria: 1) Growing patients, 7 to 9 years old. 2) All of them had CIII malocclusion due to maxillary retrusion, as verified by clinical and radiographic examinations. 3) SNA <79. 4) ANB angle <-1. 5) All patients were in the early mixed dentition. The operator excluded patients with congenital anomalies and systemic conditions from the study.

Before and after maxillary protraction records, including extraoral and intraoral photographs, study models, panoramic radiographs, and lateral cephalometric radiographs, were obtained.

The Intervention

For maxillary protraction, the clinician used a combination of palatal plate and facial masks. The modified palatal plate was custom-made and adapted for each patient. The straight surgical miniplate (Ref 55-0851, Stryker Leibinger, Germany) was supplied. The first step was to bend the plate into a semicircular configuration using a freehand technique with three peak-bending pliers. Then, the miniplate was adapted to the palatal area of the patient's model. The maximum height of the contour of the semicircular plate was placed posteriorly, not extending beyond the line connecting the distal surfaces of the upper second deciduous molars. Next, the two arms were extended anteriorly to adapt to the deciduous canine on both sides. The two arms were raised above the deciduous canines to prevent pressure on the canines during elastic loading and maxillary protraction. End holes of the plate were cut using a carbide disc to serve as hooks for elastic loading. The last fabrication step was plate finishing and smoothening (Figure 1).

The palatal plate was fixed to the palate using four surgical self-drilling screws 2.1 mm in diameter and 11 mm in length (Ref 50-20706 Stryker Leibinger, Germany). The screws were inserted perpendicular to the sides of the palate; two screws on each side (Figure 2).

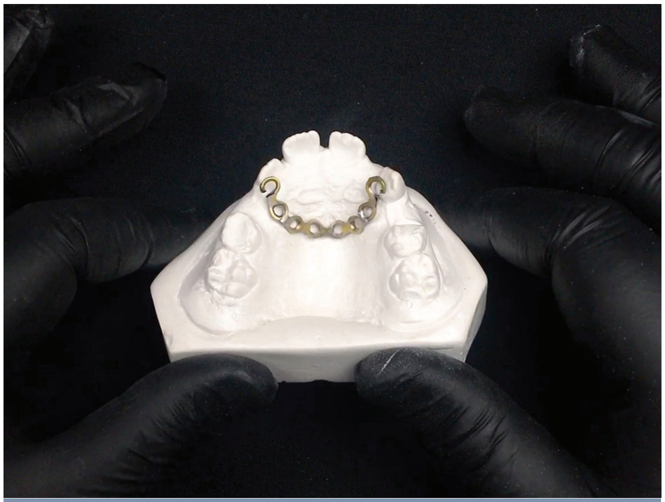

Figure 1. Adaptation of the plate on the patient's model

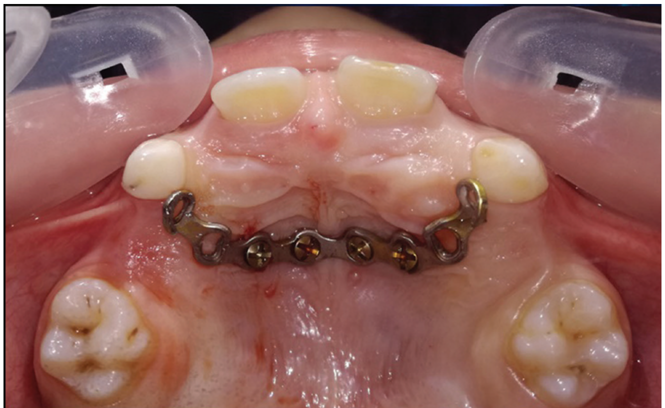

Figure 2. Occlusal view of the palatal plate after its fixation to the palate

The patients were instructed to take oral antibiotics, analgesics, and chlorhexidine mouthwash and were allowed 3 weeks to adapt to the miniplate before loading the elastics.

Application of the Facemask

After 3 weeks of fixation, the operator examined the patients to ensure that the palate plate was stable and not irritant to soft tissue. The elastics were then loaded using training intraoral elastics (100 g) for two weeks. Then, heavy extraoral elastics 3/8 in diameter, 250-300 gram per quadrant were loaded for two months. Then, 5/16 elastics were loaded.

The operator instructed the patients to wear a face mask for at least 16 hours a day. In the first month, patients were revised once biweekly and then once a month until the end of treatment. Patients were instructed to make contact in emergencies, including screw loosening, plate mobility, pain, swelling, and other problems.

Follow-up Periods

Patients were asked to attend a follow-up session every four weeks to assess the following: patient compliance, stability of the appliance (the surgical miniplate), stability of the mini surgical screws, any soft tissue enlargement around the device, amount of correction achieved, and clarification of the progress to the parents and encouragement of compliance.

Retention and Appliance Removal

After correcting the anterior crossbite and obtaining a positive overjet, a complete set of records was obtained. The surgical miniplates were left after completion of treatment for six months; during this period, a chin cup was used for retention and follow-up monthly.

Pre- and post-treatment cephalometric radiographs were digitally analyzed using Facad® software. Four angular and three linear measurements were used to evaluate skeletal changes. The angular measurements included the SNA, SNB, ANB, and SNMP angles. Linear measurements included the maxillary, mandibular, and Wits lengths. The angles between the upper incisor to the SN plane and the lower incisor to the mandibular plane were used to evaluate dental changes. The changes in the H angle were used to evaluate soft tissue changes.

A sample of 5 cases was randomly selected and remeasured by two other specialists, whose measurements were tabulated and compared with the operator's measurements for interexaminer reliability. The Kappa test of the agreement was used.

Statistical Analysis

Statistical evaluation was performed using SPSS for Windows version 16.0 (SPSS Inc., Chicago, IL, USA). A paired t-test was used to evaluate skeletal, dental, and soft tissue changes from T1 to T2. The statistical significance level was set at 0.05.

RESULTS

Clinical Findings

The modified palatal plate facemask combination corrected the development of Class III malocclusion into a Class I relationship in 7.79±2.23 months by improving the soft tissue profile. In addition, the anterior and posterior dental relations were improved.

Miniplate Stability

All miniplates were placed in positions with excellent primary stability. However, during orthopedic maxillary protraction, two miniplates showed signs of mobility with little patient discomfort, and one miniplate was completely avulsed. In these patients, the clinician retightened the screws on loose miniplates and paused loading for one week. The surgical miniplates became stable again, and the orthopedic maxillary protraction resumed. The avulsed miniplate was replaced 3 weeks later in the same position. Surgical emergency screws with larger diameters of 2.3 mm and 11 mm in length were used to fix the plate in the palate, and maxillary protraction was continued after healing for 3 weeks. Self-drilling conventional screws were used as guides for the emergency screws. They were then inserted and removed, after which the emergency screw was reinserted.

Gingival Enlargement

Only one patient exhibited palatal mucosal enlargement around the palatal plate after six months of treatment. This enlargement was due to excessive plate pressure, so the arm was raised slightly to decrease the irritation and continue treatment.

Radiographic Findings

The sample of this study consisted of 16 patients aged 7-9 years. The mean age was 8.19±0.75. The average active phase of treatment (T2-T1) was accomplished within 7.22±1.89 months. Descriptive statistics of cephalometric measurements at assessment times are presented in Table 1. Measurements used in this study are illustrated in Table 2.

There was a (T2-T1) significant increase in the ANB angle of 4.50±1.28, ($p<0.05$) with an improvement in the Wits appraisal of 5.30±1.86, ($p<0.05$). Furthermore, this was associated with a (T2-T1) significant increase in SNA angle 3.13±1.52, ($p<0.05$) and the maxillary length 2.60±0.75 ($p<0.05$, Table 3). This was accompanied by an overall (T2-T1) significant posterior movement at point B, as evidenced by the decrease in the SNB angle of -1.38±1.86, ($p<0.05$). In contrast, mandibular length showed an insignificant decrease of -1.06±1.05, ($p=0.435$).

Vertically, there was a significant increase in the SN-MP angle of 1.46±1.96, ($p<0.05$, Table 3). Regarding dental changes, the Up1/SNP group showed a significant statistical increase of 4.56±2.25, ($p<0.05$), on the other hand, the low 1/MP group showed a significant statistical decrease -4.89±2.36, ($p<0.05$). The H angle showed a statistically significant increase 5.02±3.24, ($p<0.05$) (Table 3).

Table 1. Sample age and treatment duration

	n	Range	Minimum	Maximum	Mean±SD
Age	16	2	7	9	8.19±0.75
Treatment duration	16	6	4	10	7.22±1.89

SD, standard deviation

DISCUSSION

Class III malocclusion due to maxillary deficiency is one of the most common problems in orthodontics' daily practice. Skeletally anchored maxillary protraction using infra zygomatic or lateral pyriform surgical miniplates is an excellent alternative treatment with a high success rate for correcting middle face deficiency with maximum skeletal effects rather than undesirable dental effects.[2,3,9,10] The problem with this approach was that it required two surgeries, one for insertion and the other for removal of the surgical miniplates, with subsequent unavoidable pain and discomfort.[2] The technique was also sensitive because it required presurgical consultation, minimally invasive surgery, excellet postsurgical wound care, and orthodontic follow-up. Moreover, bilateral placement doubles the invasiveness, risks, and cost. Therefore, this procedure can be aggressive, particularly for growing patients.[11]

Class III treatment is more effective at an early stage of dentition development. This intervention maximizes the skeletal adaptation that occurs in the mid-facial region during cervical maturity stages 1 and 2, with more opening of the circummaxillary sutures.[12] The sample inclusion criteria included only patients with early mixed dentition with cervical maturity stage 1-2 mean ages of 8.19±0.75.

Table 2. Definition of linear and angular measurements

Measurement	Definition
SNA	The angle between the anterior cranial base and the NA plane
SNB	The angle between the anterior cranial base and the NB plane
ANB	SNA minus SNB (skeletal relationship in the midsagittal plane)
Mand. length	It is the distance between points Co and Gn
Maxillary length	It is the distance between points Co and A
SN/MP	The angle between the anterior cranial base SN and the mandibular plane Go Gn
Wits app.	The distance between the vertical projections of A point and B point on the occlusal plane
Up1/SNP	The angle between the long axis of the maxillary central incisor and the anterior cranial base SN plane
Low1/MP	The angle between the long axis of the maxillary central incisor and the mandibular plane Go Gn
H angle	The angle between the facial plane (N"-Pog") and the H line (Pog"-Ls)

Table 3. Linear and angular measurements

Parameter	T1 Mean±SD	T2 Mean±SD	T2-T1	p-value
SNA	77.14±2.95	80.27±3.34	3.13±1.52	0.000*
SNB	80.45±2.88	79.07±3.84	-1.38±1.86	0.010*
ANB	-3.3±1.32	1.18±1.97	4.50±1.28	0.000*
Mand. length	100.16±7.60	99.09±4.99	-1.06±1.05	0.435
Maxillary length	74.11±4.24	76.71±3.77	2.60±0.75	0.044*
SN/MP	35.13±6.57	36.58±7.13	1.46±1.96	0.009*
Wits app.	-7.69±3.19	-2.41±2.24	5.30±1.86	0.000*
Up1/SNP	106.13±5.45	110.69±7.51	4.56±2.25	0.015*
Low1/MP	87.52±7.19	82.63±5.80	-4.89±2.36	0.003*
H angle	9.15±4.36	14.17±2.3	5.02±3.24	0.000*

p: p-value for t-test for comparing between before and after treatment; *: Statistically significant at $p\leq0.05$; SD, standard deviation

The palate provided an excellent area for TADs insertion due to the thick keratinized masticatory mucosa, high accessibility, and reduced risk of root damage.[13] Moreover, it provided easy access and minimal pain, was minimally invasive as a flapless technique was used for insertion, and had a high success rate.[11] Using finite element analysis, it was found that the miniplates that were anchored palatally distributed force over the circum-maxillary sutures more evenly than the buccally anchored miniplates.[11]

Several studies[6,7] have evaluated palatal bone thickness and quality, and it was found that the thickness and density of the palatal bone are age- and sex-specific. The highest quality and density of the palatal bone were found in adults rather than in children and men. The palatal bone thickness was also the thickest in the anterior palatal area.[14] The anterior palatal area is a 10-mm high rectangular area and 20 mm-wide. The anterior boundary is an imaginary line extending 10 mm posterior to the incisive papilla, while the posterior border is 10 mm distal to the anterior line.[15] The thickness of the palatal mucosa also contributes to the success of palatal TADs. Maximum primary stability can be achieved when an adequate length of the orthodontic miniscrew is placed in areas of thinner soft tissues and thicker cortical bone.[16] The palatal mucosa provides keratinized masticatory mucosa that is firmly adherent to the underlying bone and can withstand the forces applied to it.[6,7] The thickness of the palatal mucosa is variable; it is thinnest at the midline and increases gradually laterally. The palatal mucosa also follows an anteroposterior pattern, being thin anteriorly and thicker posteriorly. Therefore, the anterior palatal region was selected for miniplate fixation in the current study. The surgical miniscrews were inserted at the angulation of the palatal bone to increase the amount of engaged bone. Increasing the length of the surgical miniscrews may provide the advantage of bicortical engagement of the palatal bone, which subsequently increases the stability of the screws.[16]

The surgical plates used in this study were mini surgical plates. These miniplates are commonly used for rigid submucosal fixation of orofacial fractures and orthognathic surgery. However, some authors used the transmucosal approach with surgical miniplates to fix fractures in the palatal and mandibular regions. The transmucosal approach minimized postoperative pain, swelling, and other surgical complications. Moreover, this approach eliminated the need for general anesthesia because it can be performed under local anesthesia.[17,18] In addition, the use of palatal plates for orthodontic purposes to enhance skeletal anchorage for maxillary molar distalization[19] and maxillary protraction[11] has also been reported.

In the current study, treatment was continued until malocclusion and a positive overjet were achieved. The palatal miniplate was left during the retention period to be ready for facemask installation in case of any relapse. Prolonged retention using a chin cup with periodic follow-up is recommended because facemask therapy does not normalize the annual rate of forward maxillary growth. Patients may resume Class III growth due to deficient maxillary growth during the follow-up period.[20]

Although the suitability of the palatal bone for supporting TADs, no previous studies have used the palatal anchorage for maxillary protraction, and only a case report[21] has been found in the literature. Most of the studies in the literature used buccally placed TADs either with an extraoral face mask[2,3,10] or intraoral Class III elastics.[22] Therefore, the findings of the current study were compared with different techniques with different points of force application and other age groups.

The protraction technique used in the current study was able to displace the maxilla forward, as evidenced by the SNA angle increase of 3.130±1.520. Furthermore, it could increase the maxillary length by 2.60±0.75 mm. This forward maxillary movement was more significant than that previously reported by a previous study,[21] who used palatal anchorage to advance the maxilla by 1.5 mm. Furthermore, the amount of forward maxillary movement obtained by the palatal anchorage in the present study was comparable to the findings of other authors[9,23] who used a buccally placed submucosal surgical miniplate facemask combination with a range of advancement between 2.83-3.42 mm. On the other hand, authors[10,22] who used more extensive surgical techniques by placing submucosal surgical miniplates posterior to the maxilla and anterior to the mandible, could provide more forward movements ranging from 4.87 to 5.81 mm. This difference may be due to the differences in the mechanics used and the age groups.

Palatally anchored maxillary protraction showed a significant increase in the vertical height of the face, as evidenced by the significant increase in the Sn/Mp angle, which caused clockwise mandibular rotation. These findings follow the findings of previous studies,[4,9,23] as the SN/MP was increased by 1.46°-2.03°. In addition, the slight-opening rotation observed in the palatally anchored facemask explains why it has more control over the SN/MP angle. This makes it a suitable treatment option for Class III horizontal growers with short faces, as the clockwise rotation observed would improve the Class III skeletal pattern with subsequent improvement in facial esthetics.

Forward maxillary displacement and backward mandibular rotation contributed to improving the anteroposterior skeletal and soft tissue patterns, as evidenced by the significant increases in the ANB angle, Wits appraisal, and H angle by 4.5°, 5.3 mm, and 5.02°, respectively. These findings were compared with those reported in previous studies[5,6,20] in which the ANB angle increased ranged from 3.08 to 5.99 and the Wits appraisal ranged from 2.87 to 7.01 mm. Several studies[24-27] have evaluated maxillary protraction using a dental-anchored maxillary expander facemask combination and found that the maxilla can be displaced by 1.5+0.75 mm in the age range between six and eleven years old, with a marked clockwise mandibular rotation of 2.3°+0.83°. The results show that the palatal plate face mask combination is the best way to treat growing Class III patients with maxillary deficiency. This is because it is a successful, non-invasive way to fix developing Class III malocclusions caused by maxillary deficiency. Moreover, this technique can be used in patients with insufficient dental support.

Despite its advantages, some undesirable dental effects of palatally anchored maxillary protraction were observed in the current study, such as protrusion of the maxillary incisors. These findings are consistent with those of Elnagar et al.,[2] except for the maxillary incisors. This discrepancy could be attributed to the difference in protraction mechanics as in the palatal-plate facemask combination. The elastics were attached between the palatal plate and facemask, passing across the incisal edges of the maxillary incisors; this might cause pressure on the maxillary incisors with subsequent proclination. Moreover, the chin pad of the facemask exerted reciprocal pressure on the mandibular incisors, with subsequent retrusion of the mandibular incisors. This unavoidable side effect of facemask therapy has been reported by all authors who used it either with skeletal[2,4,9,23] or dental anchorage.[1] On the other hand, authors[2] who used Class III elastics with skeletal anchorage did not show dental changes.

Emergency screws were used when the screw holes become too large to provide sufficient grip for the screw threads to withstand axial loads.[27] In this study, an avulsion of the palatal plate was reported in one patient. In this case, four 2.3 mm emergency screws were used in the fixation of the avulsed miniplate reported in this study.

Gingival enlargement and initial disturbance of speech were also reported. The gingival enlargement may have occurred because the surgical miniplate used in this study had no lock in its holes, as overtightening of the screws causes pressure on the palatal mucosa with subsequent gingival enlargement. The double-lock miniplate may solve this problem because it has serrations within its holes, preventing overtightening and pressing the plate against the palatal tissues.[28] The effect on speech was reversible, which may be due to the high adaptability of the tongue.

According on the findings of the present study, the palatal-plate facemask combination was a successful non-invasive method for the early correction of developing Class III malocclusions due to maxillary deficiency. Moreover, this technique can be used in patients with insufficient dental support. In addition, opening the clockwise rotation of the mandible was advantageous for horizontal growers. These changes are comparable to other invasive techniques that provide skeletal anchorage for maxillary protraction. This technique cannot be used in patients with transverse deficiency because it cannot open the mid-palatal suture. More studies are needed to obtain a deeper understanding of the skeletal and dental changes observed in the current study using three-dimensional imaging.

CONCLUSION

Based on the findings of the current study, the following conclusions were obtained:

• Palatally anchored maxillary protraction is an effective alternative treatment for developing Class III malocclusions due to maxillary deficiency.

• This technique can be used for growing patients with insufficient dental support.

• This technique is not recommended for patients with transversal deficiency as it cannot open the mid-palatal suture.

Ethics

Ethics Committee Approval: The Tanta University Faculty of Dentistry Research Ethics Committee approved the study protocol (approval no.: #R-ORTH-11-17-1, date: on April 2022).

Informed Consent: In addition, written informed consent was obtained from all participants, considering the guidelines for human research adopted by the Research Ethics Committee.

Author Contributions: Concept - M.A.E., S.A.G., E.E.-S.; Design - M.A.E., S.A.G., E.E.-S.; Data Collection and/or Processing - M.A.E., S.A.G., E.E.-S.; Analysis and/or Interpretation - M.A.E., S.A.G., E.E.-S.; Literature Review - M.A.E., S.A.G., E.E.-S.; Writing - M.A.E., S.A.G., E.E.-S.

Conflict of Interest: The authors have no conflicts of interest to declare.

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