Original Article

Skeletal and dental effects of a new compliance-free appliance, the NET3 corrector, in management of skeletal Class III malocclusion compared to rapid maxillary expansion-facemask

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ABSTRACT

Objectives: To examine retrospectively the short-term effects of a compliance-free skeletal Class III corrector (NET3-corrector) compared to rapid maxillary expansion-facemask (RME-FM).

Material and Methods: Records of 20 skeletal Class III patients treated with the NET3-corrector were compared to 20 patients treated with RME-FM, mean age: 11.14 ± 1.17 years and 11.14 ± 2.06, respectively. The NET3-corrector consisted of a hybrid-expander, a lower lingual arch, and a modified PowerScope spring. The RME-FM group received an RME-facemask combination. T2 records were collected when an overjet of at least 2 mm was achieved. Differences between two timepoints within groups and differences between groups were tested using paired samples *t*-test and independent samples *t*-test, respectively ($P < .05$ was considered statistically significant).

Results: The treatment time was 10.5 months with NET3-corrector and 12 months with RME-FM. The NET3-corrector was well tolerated by patients and the Class III malocclusion was corrected in all patients in both groups. The overall maxillary skeletal change was greater with the NET3-corrector, with an additional 2° advancement at SNA ($P < .001$). Significant differences in maxillary incisor angulation were observed in the RME-FM group in comparison to NET3 (−0.37 ± 3.31 vs 4.96 ± 3.80; $P < .001$). The mandibular molars tipped significantly more distally in the NET3 group (7.3° more; $P < .001$).

Conclusions: The compliance-free tooth-bone-borne NET3-corrector, is effective in correcting Class III malocclusion with improved maxillary skeletal outcomes compared to RME-FM in the short term. These results need to be evaluated in the long term with a randomized sample. (*Angle Orthod*. 2025;95:274–282.)

KEY WORDS: Skeletal Class III; MARPE; Facemask; Compliance free

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Accepted: November 24, 2024. Submitted: December 18, 2023. Published Online: February 14, 2025

INTRODUCTION

The most used conventional treatment for skeletal Class III patients is the rapid maxillary expansion (RME) and facemask (FM) combination. FM is advised to be worn for 14–16 hours per day, for a period of 9–12 months.[1] Since it is an obtrusive extraoral appliance, wear time is usually less than prescribed.[2,3] Also, due to the tooth-borne nature of force application, there are undesirable dental side effects.[4] This is further accentuated in patients in late mixed dentition as there is poor dental anchorage available. Skeletal anchorage methods were introduced to overcome some of the limitations of conventional facemask therapy. DeClerck et al. (2010) used skeletal miniplates to apply the elastic traction directly to bone, whereas Wilmes et al. (2010) used palatal miniscrews to provide anchorage for maxillary expansion during protraction, as well as a skeletal anchorage plate in the anterior symphysis, Mentoplate, for Class III elastic traction.[5–7]

These skeletally anchored/hybrid appliances were reported to show improved outcomes in some studies,

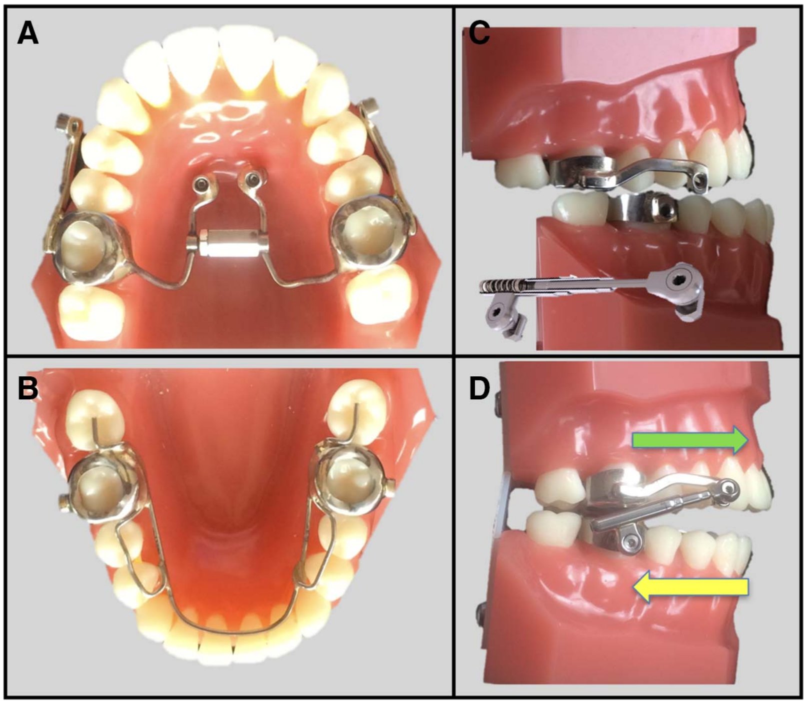

Figure 1. NET3-corrector typodont. (A) Maxillary appliance; (B) Mandibular appliance; (C) Lateral view without PowerScope spring; (D) With spring.

surpassing the skeletal effects produced by RME-FM, while eliminating the dental side effects.[5,7–9] Others, however, failed to show significant skeletal differences.[10] This was related to a few factors, including the young age of patients in some studies, but also the fact that these modern techniques were still completely dependent on compliance with elastic wear. Liou et al. (2015) introduced the Alt-RAMEC (alternate rapid maxillary expansion and constriction) protocol, together with a compliance-free spring, that showed significant changes in cleft lip and palate patients.[11] However, the application of this spring is technique sensitive, as breakage may occur frequently. Another study with a fixed reverse twin block to eliminate the need for patient compliance showed similar results to facemask therapy; however, the appliance is cumbersome, and tooth borne.[12] More recently, combining a fixed Class III corrector with full fixed appliances and maxillary buccal mini-screws was used to improve skeletal outcomes without the need for compliance.[13] However, this design still caused significant dental side effects.

Therefore, there is still a need for compliance-free appliances in the management of skeletal Class III in growing children. The aim of this study was to evaluate the skeletal and dental effects of a novel compliance-free Class III corrector (the NET3-corrector) compared with the conventional RME-FM.

MATERIALS AND METHODS

The sample consisted of 40 Class III patients: 20 were selected prospectively to be treated with the NET3-corrector (by NET). Twenty age- and malocclusion-matched RME-FM patients were retrospectively selected from the archives of Ankara University. Ethical approval: 2019/ETH06473, X20-0456 and 2020/ETH02668 Sydney Local Health District Ethics Committee.

Inclusion Criteria

Skeletal Class III, cervical maturation stage up-to CS 4, 8–14 years, no previous orthodontic treatment, no craniofacial anomalies.

Exclusion Criteria

Previous orthodontic treatment, patients with syndromes or congenital anomalies.

Appliance Design

NET3-corrector: The framework consisted of crowns of Hanks telescoping Herbst (American Orthodontics, Sheboygan, WI, USA), in reverse configuration (Figures 1 and 2). The expander was a hybrid design, with two palatal miniscrews (2 × 9 mm; PSM Medical Solutions, Gunningen, Germany), and a 12 mm SuperScrew (The SuperScrew-SuperSpring Co. Los Angeles, CA, USA). Protraction was applied via the PowerScope (American Orthodontics) telescopic bite jumper used in reverse, applying 260 g force.[14] The commercially available PowerScope spring is designed to have a reversed thread on one side, so it did not fit the Hanks Herbst nut. A special version of the PowerScope was manufactured for this study.

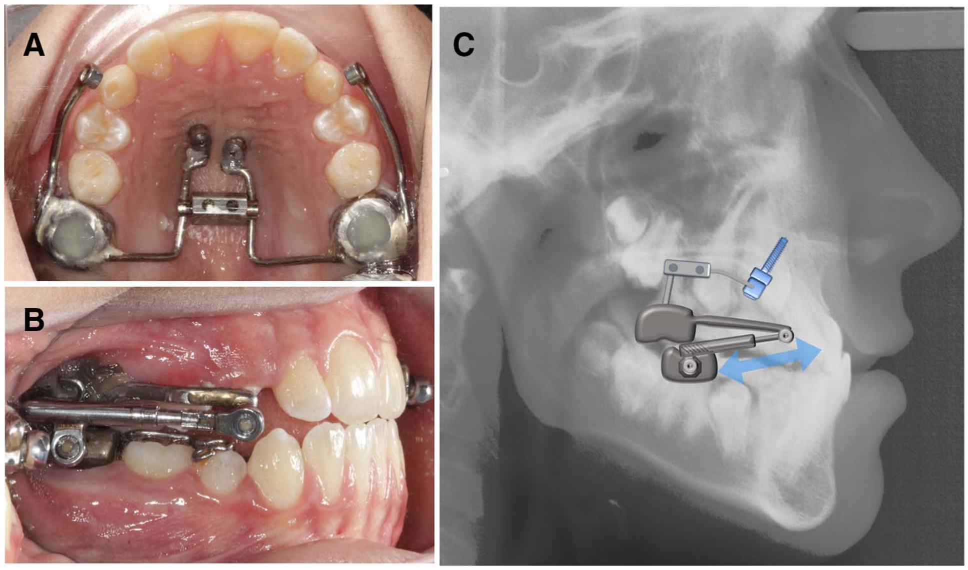

Figure 2. The NET3-corrector intra-oral view. (A) Maxillary appliance; (B) Active appliance; (C) Diagrammatic illustration.

The Hanks cantilever arms were welded to the upper first molar modified crowns (Rollo Bands; American Orthodontics; Figures 1 and 2). A lower lingual arch was present and the Hanks Herbst nut was welded to the buccal surface of the lower first molars. After cementation, patients were instructed to start expansion with two turns a day for 3 weeks. The PowerScope spring was then connected. Patients were then requested to continue to expand the appliance once a day until the desired expansion was achieved. Patients were reviewed every 6–8 weeks to assess the activity of the springs (Figure 2). As the occlusion gradually corrected, reactivation was performed by adding shims (American Orthodontics,) to the telescoping arms.

RME-FM Group

This group was treated with a bonded RME (Figure 3).[15] Patients were instructed to turn the expansion mechanism once a day for 3 weeks, after which the facemask was started. They then continued at the same rate until the desired expansion was achieved. The patients were instructed to wear the facemask for 14–16 hours every day with an elastic force of 400 g per side.

Cephalometric Analysis

Records were obtained before treatment (T1) and post treatment (T2) when positive overjet of at least 2 mm was achieved. For the NET3 corrector group, lateral

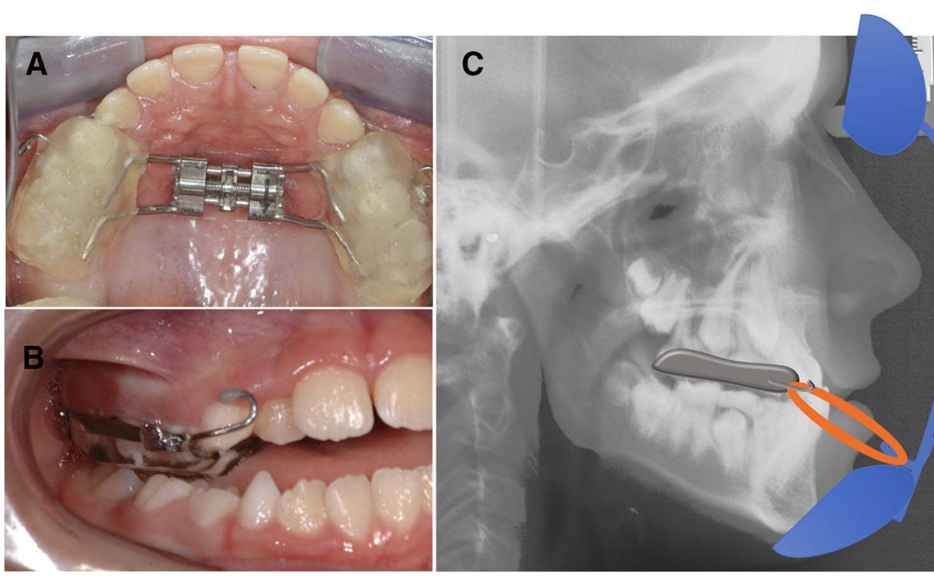

Figure 3. (A) Bonded RME occlusal view; (B) Lateral view; (C) Diagrammatic illustration. RME indicates rapid maxillary expansion.

Table 1. Intraclass Correlation Coefficient for Intra-Observer Reliability

	Intraclass Correlation
SNA°	0.994
SNB°	0.993
ANB°	0.994
Wits mm	0.988
A-TV mm	0.984
B-TV mm	0.993
PP-MP°	0.991
SN-MP°	0.987
UOP-PP°	0.981
LOP-MP°	0.946
U1-SN°	0.994
U1-PP°	0.995
U6-PP°	0.981
L1-MP°	0.868
L6-MP°	0.99
Overjet mm	0.985
Overbite mm	0.989

cephalometric radiographs were created using the readily available cone beam computed tomography (CBCT) radiographs. For the RME-FM patients, lateral cephalometric radiographs were taken before and after treatment.

All cephalograms were digitized and traced by the same examiner using OrthoTrac V11.7.0.32 (Carestream Dental, Atlanta, GA, USA), matching the magnification of CBCT data to that of the lateral cephalograms used for RME-FM patients. Intra-observer reliability was tested by retracing radiographs of 11 randomly selected patients 1 month apart.

Statistical Analysis

The sample size was calculated using G*Power software (G*Power Version 3.1.9.6, Franz Faul, University of Kiel, Germany) based on previous data[16] and using a two-tailed *t*-test and $\alpha = 0.05$, power $= 0.80$; a sample size of 18 patients for each group was needed. This study was planned as a prospective clinical trial, although the results are presented in a retrospective fashion. Therefore, to account for dropouts, 20 patients were recruited for the study and the results of all patients were analyzed and reported.

IBM SPSS Statistics software (version 23.0. Armonk, NY: IBM Corp.) was used to analyze the data. Normality and homogeneity of variance of the data were assessed using Shapiro-Wilk's test and Levene's test for equality of variances, respectively. Differences between two timepoints within groups were tested for significance using paired samples *t*-test. Differences between groups were tested for significance using an independent samples *t*-test.

RESULTS

The intraclass correlation coefficients (ICC) showed excellent reliability, with values ranging between 0.981 and 0.993, except the L1-MP, for which inter-rater reliability was still high at 0.868 (Table 1). The cephalometric variables used in the analysis are illustrated in Figure 4.

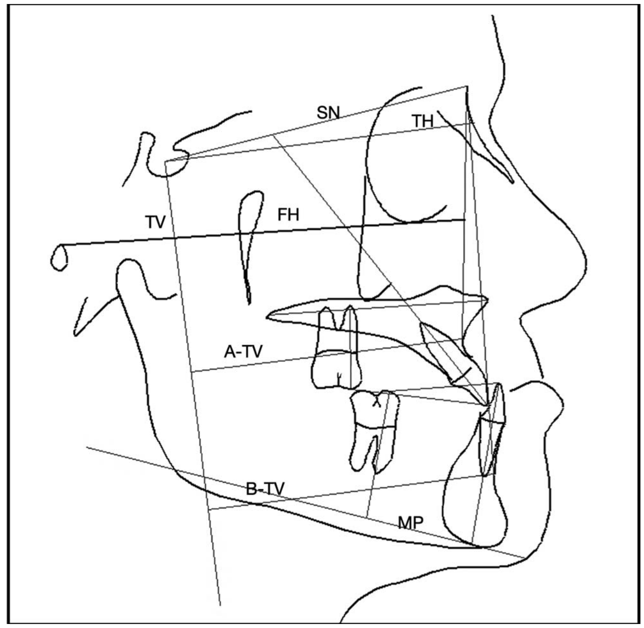

Figure 4. Cephalometric measurements: SN (Sella-Nasion). TH (true horizontal line: $-7°$ from SN). TV (true vertical line: perpendicular to TH through Sella). A-TV (perpendicular distance from A-point to TV). B-TV (perpendicular distance from B-Point to TV). FH (Frankfort horizontal). PP (palatal plane, ANS-PNS). MP (mandibular plane). UOP (upper occlusal plane: maxillary incisal tip to mesiobuccal cusp of first molar). LOP (lower occlusal plane: mandibular incisor tip to mesiobuccal cusp of mandibular first molar). U1 (long axis of upper central incisor). L1 (long axis of mandibular central incisor). U6 (maxillary first molar long axis). L6 (mandibular first molar long axis).

Pretreatment age and treatment duration and demographics of both groups are presented in Table 2. The two groups were similar before treatment. The mean treatment time was 10.5 months (SD $= 3.3$) with NET3-corrector and 12 months (SD $= 3.5$) with RME-FM.

There were significant treatment changes from T1 to T2 for most parameters in both groups with treatment (Table 3). The NET3-corrector appliances were reasonably well-tolerated by the patients, and the anterior crossbite was successfully corrected in all patients. Pre- and post-treatment photos of a patient treated with NET3-corrector are shown in Figures 5 and 6.

Comparison between the two groups (Table 3) showed significant differences in several parameters. The SNA angle showed a significantly greater advancement in the NET3 group, with a further 2° increase ($P < .001$), while the reduction in the SNB angle was 1.1° greater for the RME-FM group ($P < .05$). Both the ANB and Wits changes were also slightly greater for the NET3 group, although this was not statistically significant for Wits. In the vertical dimension, there was slightly greater but not

Table 2. Comparison of the Two Groups at T1, Before Treatment

	NET3-Corrector (n = 20) Females: 9, Males: 11		RME-FM n = 20 Females: 7, Males: 13		95% Confidence Interval of the Difference		
	Mean	Std. Deviation	Mean	Std. Deviation	Lower	Upper	*P*
Age at T1, y	11.14	1.17	11.14	2.06	−1.07	1.07	1.00
Tx Duration, mo	10.6	3.2	12	3.5	−3.6	0.7	.18
SNA°	79.40	2.76	77.85	3.22	−0.36	3.47	.11
SNB°	80.47	3.12	79.73	2.91	−1.19	2.67	.44
ANB°	−1.10	2.04	−1.90	1.56	−0.36	1.96	.17
Wits mm	−4.44	2.31	−5.00	2.49	−0.97	2.10	.46
A-TV mm	57.20	2.45	58.21	3.51	−2.95	0.93	.30
B-TV mm	56.90	5.47	57.96	4.84	−4.36	2.24	.52
PP-MP°	26.18	6.67	24.47	4.26	−1.88	5.29	.34
SN-MP°	33.65	6.13	33.82	4.83	−3.70	3.36	.92
UOP-PP°	12.37	4.43	10.63	5.14	−1.33	4.82	.26
LOP-MP°	20.40	3.92	20.60	3.79	−2.66	2.27	.87
U1-SN°	106.19	6.32	104.25	5.29	−1.79	5.68	.30
U1-PP°	113.68	5.71	113.61	5.76	−3.60	3.75	.97
U6-PP°	77.77	4.37	81.00	3.94	−5.90	−0.57	.02
L1-MP°	87.78	6.25	86.15	5.99	−2.29	5.55	.41
L6-MP°	81.31	6.07	77.76	5.24	−0.08	7.18	.06
Overjet mm	−1.50	1.97	−2.11	1.61	−0.54	1.77	.29
Overbite mm	1.38	2.23	1.51	2.58	−1.68	1.41	.86

significantly different increase in the mandibular plane angle in the RME-FM group.

The maxillary incisors and first molars proclined more in the RME-FM group, ($P < .001$). This change was not significant for the NET3-corrector group for the incisors, while it was significant for the first molars ($P < .001$). There was no statistically significant difference between the groups for lower incisor retroclination. The mandibular molars tipped significantly more distally with the NET3, 7.3° more than was observed with RME-FM ($P < .001$).

NET3 Complications

Only one miniscrew failure occurred in the NET3 group, which happened prior to appliance insertion, so a new miniscrew was inserted and the appliance was remade. There was one case in which the cantilever arm fractured from the maxillary molar band, and two instances of appliance debonding, once in the maxilla and once in the mandible. The most recurring problem was loosening of the modified PowerScope spring. This occurred exclusively on the lower left-hand side for every patient, and the

Table 3. Treatment Changes for Both Groups From T1 to T2 and Their Comparison

	NET3-Corrector							RME-FM			
	T1		T2		95% CI			T1		T2	
	Mean	SD	Mean	SD	Lower	Upper	p	Mean	SD	Mean	SD
SNA°	79.40	2.76	82.54	3.24	2.23	4.04	0.00	77.85	3.22	78.90	3.31
SNB°	80.47	3.12	80.62	3.16	−0.72	1.02	0.72	79.73	2.91	78.77	2.82
ANB°	−1.10	2.04	1.92	1.89	2.37	3.66	0.00	−1.90	1.56	0.12	1.37
Wits	−4.53	2.33	0.00	2.53	3.47	5.59	0.00	−5.00	2.49	−1.61	2.05
A-TV	57.20	2.45	60.83	2.67	2.7	4.56	0.00	58.21	3.51	59.79	3.68
B-TV	56.90	5.47	57.23	3.83	−2.02	2.68	0.77	57.96	4.84	56.90	4.67
PP-MP°	26.18	6.67	26.83	5.55	−0.71	2.01	0.33	24.47	4.26	25.85	3.95
SN-MP°	33.65	6.13	34.19	5.52	−0.52	1.6	0.30	33.82	4.83	34.85	4.19
UOP-PP°	12.37	4.43	12.57	4.36	−1.89	2.28	0.85	10.63	5.14	9.58	4.71
LOP-MP°	20.40	3.92	22.71	3.78	0.8	3.81	0.01	20.60	3.79	22.78	4.02
U1-SN°	106.19	6.32	105.83	5.89	−1.91	1.18	0.63	104.25	5.29	109.20	5.15
U1-PP°	113.68	5.71	113.22	5.98	−1.84	0.92	0.49	113.61	5.76	118.19	5.53
U6-PP°	77.77	4.37	80.31	4.89	1.67	3.41	0.00	81.00	3.94	84.00	3.93
L1-MP°	87.78	6.25	83.03	6.69	−6.77	−2.72	0.00	86.15	5.99	81.19	6.82
L6-MP°	81.31	6.07	73.60	7.57	−10.16	−5.26	0.00	77.76	5.24	77.77	5.36
Overjet	−1.50	1.97	2.78	1.08	3.29	5.25	0.00	−2.11	1.61	2.77	0.85
Overbite	1.38	2.23	1.10	1.36	−1.06	0.5	0.46	1.51	2.58	1.77	1.52

springs were simply reattached. The patients were able to reattach the spring using the Allen key supplied. The telescoping arm broke in three instances and a new modified PowerScope was placed. The results of these patients are included in the study.

DISCUSSION

The novel, compliance-free Class III orthopedic corrector, NET3, successfully corrected Class III malocclusion by maxillary skeletal protraction and some dental changes in all patients included in this study. The skeletal and dental changes exhibited by the active controls using RME-FM in this study were consistent with results from other studies using similar methodology, making this study's RME-FM group a good comparative group.[17–19] The maxillary skeletal changes produced by NET3 were slightly more pronounced compared to RME-FM, although there was variable response. Although NET3 did not have any significant effect on SNB, there was reduction in the RME-FM group, which was mainly due to posterior mandibular rotation.

The protraction spring by Liou et al. (2005) showed significant changes of maxillary position in cleft lip and palate patients but, compared to facemask, there was no significant difference.[11,20,21] This could have been due to the tooth borne nature of force application. Meazzini et al. (2021) combined the protraction spring with interradicular miniscrews and alternating expansion constriction protocol and showed significant changes to the maxilla with minimal dental side effects. However, their results were not compared to facemask.[22]

In this study, the use of skeletal anchorage in the maxilla for NET3 patients reduced the undesirable dental side effects usually seen with maxillary protraction, although it was not fully eliminated. There was some maxillary molar tipping in both groups. The NET3-corrector group showed 2.5° of mesial molar tipping despite the use of skeletal anchorage.[19] This was likely due to wire flexion in the appliance, and possible tipping of mini-screws under loading.

Although the RME-FM group showed a significant increase in the upper incisor inclination, there was no significant change in the NET3-corrector group. Other studies with maxillary protraction using the Hybrid Hyrax and facemask have also shown minimal dental side effects.[8,9,19,23]

Mandibular incisor retroclination was similar for both groups. However, the NET3-corrector had the additional effect of tipping the mandibular molars distally, causing counterclockwise rotation of the mandibular occlusal plane and a posterior open bite. This was also reported with another spring and can be expected to rebound after treatment.[11] For this reason, the mandibular component is not cemented on any other mandibular teeth, to avoid the side effects being carried over. The number of teeth included in the NET3-corrector is an advantage over the conventional RME-FM in that it does not include any teeth except the first molars in either jaw, so it can be used effectively in the transitional stage of the late mixed dentition.

Another study to date used buccal skeletal anchorage with a fixed Class III corrector, a reverse Forsus FRD (3M Unitek Corp, Monrovia, CA, USA) supported by two interradicular maxillary buccal miniscrews,[13] inserted buccally between maxillary canines and first premolars and secured to the canines. This

Table 3. Extended

RME-FM			T2-T1 Change Comparison NET3-Corrector vs RME-FM							
95% CI			NET3 T2-T1		RME-FM T2-T1		95% CI		
Lower	Upper	p	Mean	SD	Mean	SD	Lower	Upper	p
0.64	1.46	0.00	3.14	1.94	1.05	0.87	1.12	3.05	0.00
−1.54	−0.39	0.00	0.15	1.86	−0.97	1.22	0.11	2.12	0.03
1.56	2.47	0.00	3.02	1.38	2.02	0.97	0.24	1.76	0.01
2.72	4.07	0.00	4.53	2.20	3.40	1.44	−0.07	2.34	0.06
1.14	2.01	0.00	3.63	1.99	1.58	0.94	1.06	3.05	0.00
−1.91	−0.21	0.02	0.33	5.02	−1.06	1.81	−1.03	3.81	0.25
0.31	2.45	0.01	0.65	2.92	1.38	2.29	−2.41	0.95	0.39
0.25	1.8	0.01	0.54	2.26	1.03	1.66	−1.75	0.78	0.44
−2.43	0.34	0.13	0.20	4.46	−1.05	2.95	−1.18	3.66	0.31
0.59	3.77	0.01	2.31	3.22	2.18	3.39	−1.99	2.24	0.91
3.18	6.73	0.00	−0.37	3.31	4.96	3.80	−7.6	−3.04	0.00
2.74	6.42	0.00	−0.46	2.94	4.58	3.94	−7.27	−2.81	0.00
2.22	3.78	0.00	2.54	1.86	3.00	1.66	−1.59	0.67	0.41
−6.51	−3.41	0.00	−4.75	4.33	−4.96	3.31	−2.25	2.68	0.86
−2.55	2.57	0.99	−7.71	5.23	0.01	5.47	−11.15	−4.29	0.00
3.96	5.8	0.00	4.27	2.10	4.88	1.97	−1.91	0.69	0.35
−0.79	1.31	0.61	−0.28	1.67	0.26	2.23	−1.8	0.72	0.39

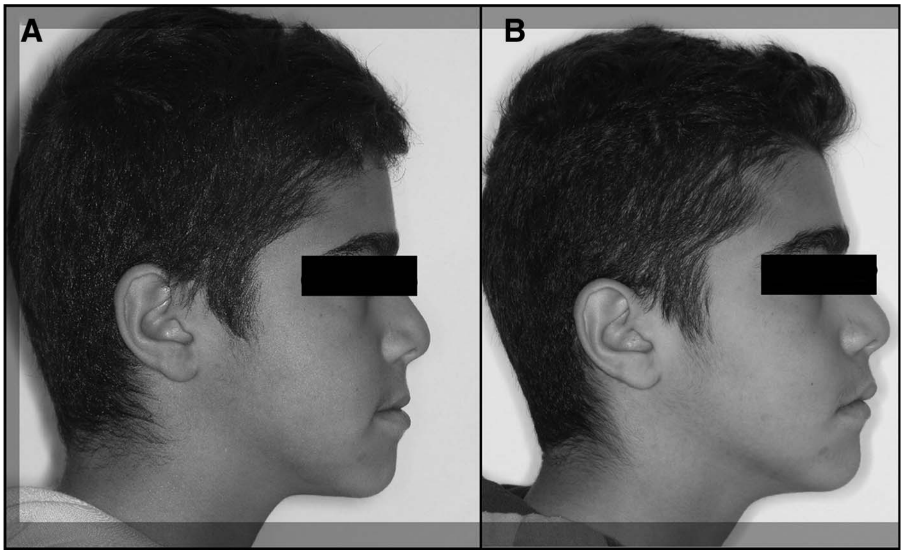

Figure 5. Profile before (A) and after (B) treatment.

design is significantly different from that of the NET3-corrector, which may explain some of the differences in findings. First, the NET3-corrector does not require full banding of the upper and lower teeth; anchorage is only gained from the permanent first molars and two palatal miniscrews; therefore, it can be used even when the premolars and canines have not yet erupted. If using Forsus, the dental arches must be worked up to a rigid archwires, significantly delaying the onset of treatment. This may explain the superior maxillary protraction with the NET3-corrector. Additionally, miniscrew placement in the palate is safer, with no chance of root injury and a higher documented success rate.[24] Paramedian palatal placement allows miniscrews be used for simultaneous maxillary expansion, which is often needed in Class III cases.

The facemask or the functional Class III correctors are obtrusive devices and, therefore, patient acceptance can be low. Class II treatment with fixed bite correctors was shown to be more predictable than elastics or removable appliances.[25] The NET3-corrector was able to achieve comparable, if not slightly better, results than the facemask, while eliminating the need for compliance. Though BAMP and Hybrid Hyrax-Mentoplate protocols[5,9] also eliminated the need for facemask wear, both are still reliant on patients wearing elastics. Additionally, both methods require flap surgery with the added discomfort after surgery, cost, and inconvenience.

Clinically, the NET3-corrector was well tolerated by the patients. However, some clinical problems were reported such as loosening of the PowerScope spring on the lower left, potentially related to function and mandibular movement leading to gradual unwinding. An effective remedy could be to reverse the threads on the left-hand side screws. There were also two incidences of fracture of the welding which can be addressed with CAD/CAM manufacturing.

Limitations

Limitations of this study included the wide age range of patients, as well as the retrospective nature of the analysis. All patients in this study achieved positive overjet; however, the RME-Facemask group was not treated prospectively. Blinding of the post-treatment radiographs of NET3 patients was also not possible due to the miniscrews on the palate. Compliance was not monitored in the facemask group; however, this reflects the real clinical situation. The results need to be tested in a randomized clinical trial with a larger patient sample from young and older age groups. Long term follow-up of these patients is also necessary.

CONCLUSIONS

- The compliance-free, NET3-corrector is effective in correcting skeletal Class III malocclusion in growing children in the short term and is well-tolerated by patients.
- Correction comes mostly from maxillary skeletal protraction and mandibular dental compensation.
- Effects were comparable yet slightly better than what is achieved with conventional RME-facemask.
- This appliance could offer a compliance-free method for managing skeletal Class III malocclusion in mild and moderate cases.

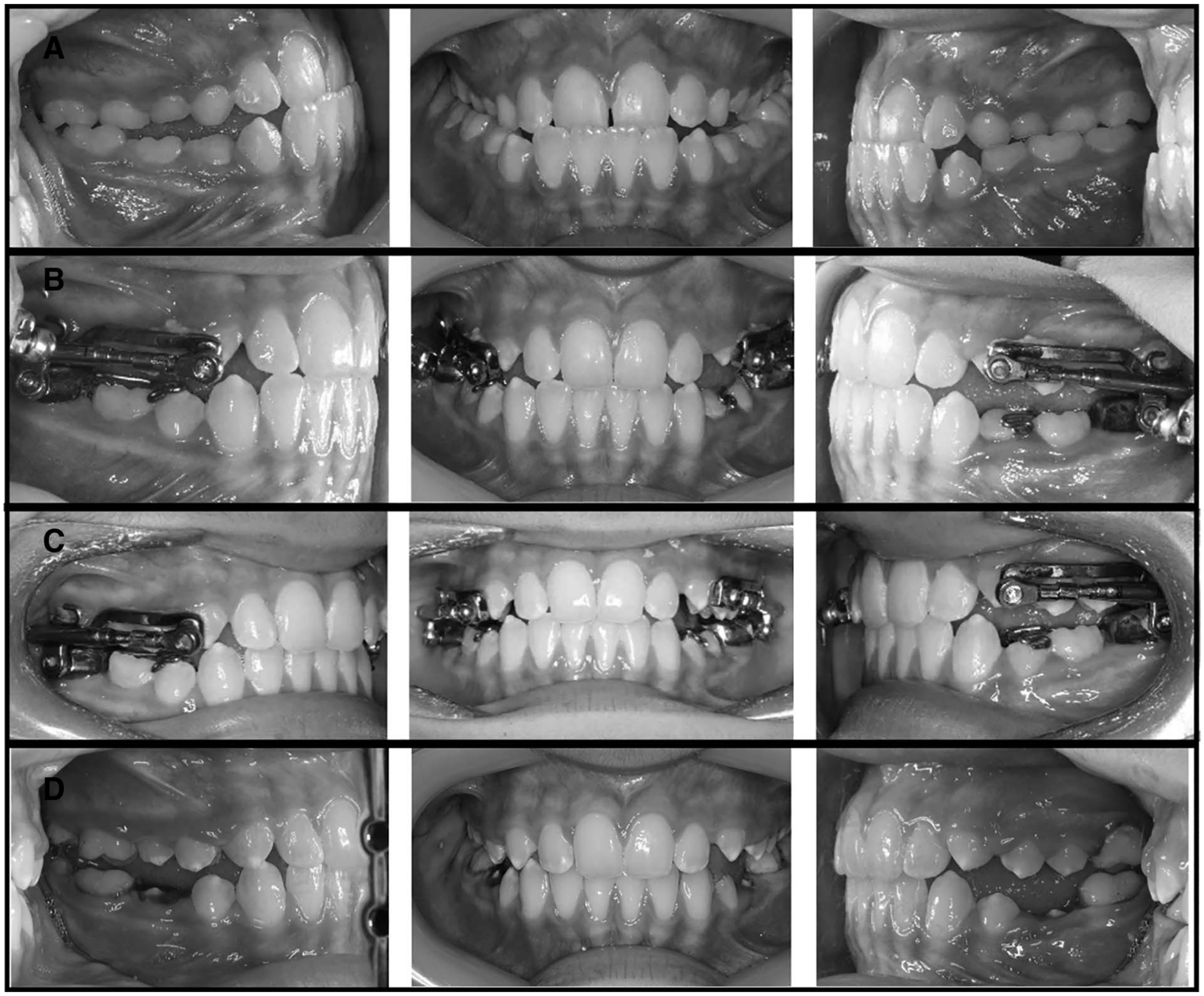

Figure 6. Treatment progress with NET3-corrector. (A) Before treatment; (B) Initial activation; (C) 6 months progress with reactivation of the spring, (D) Corrected malocclusion.

ACKNOWLEDGMENT

The study was funded by the Australian Society of Orthodontics Foundation for Research and Education.

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