Molar inclination and surrounding alveolar bone change relative to the design of bone-borne maxillary expanders: A CBCT study

Hyung-Wook Moon; Min-Jung Kim; Hyo-Won Ahn; Su-Jung Kim; Seong-Hun Kim; Kyu-Rhim Chung; Gerald Nelson

ABSTRACT
Objective: To evaluate the molar inclination and skeletal and alveolar bone changes when comparing tooth bone-borne (MSE) and tissue bone-borne type maxillary expanders (C-expander) using cone-beam computed tomography (CBCT) in late adolescence.

Materials and Methods: A sample of 48 late-adolescent patients were divided into two groups according to the type of expander: MSE group (n = 24, age = 19.2 ± 5.9 years) and C-expander group (n = 24, age = 18.1 ± 4.5 years). CBCT scans were taken before treatment and 3 months after expansion. Transverse skeletal and dental expansion, alveolar inclination, tooth axis, buccal alveolar bone height, thickness, dehiscence, and fenestration were evaluated on the maxillary first molar. Paired t-test, independent t-test, Pearson’s chi-square test, and Spearman correlation analysis were performed.

Results: The MSE group produced greater dental expansion (P < .05), whereas skeletal expansion was similar in both groups (P = .859). The C expander group had more alveolar bone inclination change (P < .01), and the MSE group had more buccal tipping of the anchorage teeth (P < .01 or .001). Buccal alveolar bone height loss and thickness changes were greater in the MSE group (P < .01 or <.001). Formation of dehiscences was more frequent in the MSE group (P < .001), whereas for fenestrations, there were no significant differences between the two groups. Buccal bone height loss in the MSE group had a negative correlation with initial buccal bone thickness.

Conclusions: The incorporation of teeth into bone-borne expanders resulted in an increase in the severity of side effects. For patients in late adolescence, tissue bone-borne expanders offer comparable skeletal effects to tooth bone-borne expanders, with fewer dentoalveolar side effects. (Angle Orthod. 2020;90:13–22.)

KEY WORDS: Rapid maxillary expansion; Maxillary skeletal expander; C-Expander; C-implant; CBCT; Nasomaxillary complex
INTRODUCTION

Transverse deficiency of the maxilla is a prevalent orthodontic problem, and it often is accompanied by unilateral or bilateral posterior crossbite and crowding. This malocclusion has a very low chance of spontaneous correction and can adversely affect not just the developing permanent dentition but also craniofacial growth and its functions.\(^1-3\) Studies\(^4-6\) confirm that such individuals benefit from rapid palatal expansion (RPE), preferably in the growing patient, before calcification of the numerous craniofacial sutures, including the midpalatal suture. However, conventional tooth-borne—type rapid maxillary expansion (RME) is associated with side effects such as buccal tipping of the alveolar bone, tipping of the tooth axes, root resorption, decrease in buccal bone thickness, and marginal bone height resulting in buccal dehiscence.\(^7-10\) In adults with heavily interdigitated sutures, conventional RME treatment is less effective. Therefore, in order to overcome the limitations of tooth-borne RME, reports\(^11-13\) have demonstrated different designs of bone-borne palatal expanders anchored with mini-screws and have suggested the superior performance of bone-borne—type RME.

However, in previous studies\(^14\) there were variations in the design of the bone-borne type expanders and a lack of comparison between the different designs, rendering the clinical choice for the best type of appliance difficult. Recent finite element analysis studies\(^15,16\) reported that different designs of RMEs had different stress distributions, stability, and displacement.

In cone-beam computed tomography (CBCT) studies,\(^17,18\) voxel-based three-dimensional (3D) superimposition methods were introduced to minimize measurement error, and they were reported as suitable for research in both growing and grown patients. The immediate effects of transverse skeletal and dentoalveolar changes in tooth-borne and bone-borne expanders have already been compared in a previous CBCT study.\(^12\) In the present study, anchorage tooth inclination and buccal alveolar bone changes of two types of bone-borne RME (tooth bone-borne maxillary expander, tissue bone-borne maxillary expander) were compared in late-adolescent patients using the voxel-based 3D superimposition method.

MATERIALS AND METHODS

Subjects

The subjects were 48-patients who had maxillary expansion treatment using a bone-borne expander within the Department of Orthodontics at the Kyung Hee University Dental Hospital between 2011 and 2017. They were divided into two groups according to the type of expander used: tooth bone-borne maxillary expander (Maxillary-Skeletal-Expander; MSE, \(n = 24\), age = 19.2 ± 5.9 years) and tissue bone-borne maxillary expander (Biocreative-Expander; C-expander, \(n = 24\), age = 18.1 ± 4.5 years) (Table 1). The inclusion criteria for sampling were as follows: a complete set of CBCT images acquired before (T1) and 3 months after (T2) expansion were available, a transverse maxillary deficiency with unilateral or bilateral posterior crossbite, over 7 mm of activation, and no surgical or other treatment that might influence the anchorage teeth and the expansion outcome during the expansion period. Some samples were excluded on the basis of the following exclusion criteria: systemic diseases, craniofacial anomalies, failure of opening of the midpalatal suture, or fracture or partial removal of the expansion device during the expansion period. This retrospective study was performed under approval from the Institutional Review Board of Kyung Hee University, Dental Hospital (IRB-1805-01).

Maxillary Expander Design and Activation Protocol

The MSE appliance was composed of four 1.5-mm-diameter stainless-steel arms soldered to the bands and Hyrax expansion screw to stabilize the posterior dental segment (BioMaterials Korea Inc, Seoul, Korea) (Figure 1A,B). Four mini-screws (1.5 mm in diameter, 11 mm in length) were used for fixation of the expander to the palate. The device was activated at a rate of one turn per day (0.20 mm widening) until the required expansion was achieved. The C-expander (Figure 1C,D) was composed of expansion screws supported by four mini-implants (C-implant; Cimplant Co, Seoul, Korea), with a diameter of 1.8 mm and a length of 8.5 mm implanted through the resin part of the expander on the palatal slope (Forestadent Co, Pforzheim, Germany). C-implants were located between the canines and first premolars and two between the second premolars and first molars. Maxillary expansion was initiated on the day that the expander was delivered. The device was activated at a rate of two turns per week (0.45 mm widening) until separation of the midpalatal suture; after separation, one turn per day was utilized until the required expansion was achieved.

CBCT Protocol

CBCT scans were taken with a 0.39-mm\(^3\) voxel size level (Alphad Vega, Asahi Roentgen, Kyoto, Japan: 10 mA, 80 kV, and 30-second scan time). The data obtained were imported as DICOM-files using OnDemand-3D™ software (Cybermed, Daejeon, Korea). To
set reference planes for consistent measurements, the CBCT images were superimposed using voxel-based rigid registration of selected anterior cranial base volumes (Figure 2). T1 and T2 images were reoriented along the palatal suture (x-plane), parallel to the palatal plane (y-plane) and tangent to the nasal floor (z-plane) in axial, sagittal, and coronal sections, respectively. By identifying the coordinate system of T1 and T2 the measurement errors could be minimized. Transverse skeletal expansion was evaluated at the suture of the nasal floor level. Transverse dental expansion was measured at the central fossa level (Figure 3A). On the mesiobuccal cusp and central fossa section, tooth axis and alveolar inclination, buccal alveolar bone height, and dehiscences (Figure 3B,C) were measured. Buccal alveolar bone thickness measurements were made from the outermost point of the bones to the roots at the level of the furcation point, and fenestra-

Table 1. Characteristics of Subjectsa

<table>
<thead>
<tr>
<th></th>
<th>MSE</th>
<th>C-Expander</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>24 (M, 14; F, 10)</td>
<td>24 (M, 5; F, 19)</td>
<td></td>
</tr>
<tr>
<td>Skeletal classification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class I</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Class II</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Class III</td>
<td>13</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Age at treatment initial, y</td>
<td>19.2 ± 5.9</td>
<td>18.1 ± 4.5</td>
<td>.480</td>
</tr>
<tr>
<td>Time from initial to end of expansion, mo</td>
<td>1.2 ± 0.6</td>
<td>3.1 ± 1.7</td>
<td>.000††</td>
</tr>
</tbody>
</table>

a MSE indicates tooth bone-borne maxillary expander; C-Expander, tissue bone-borne maxillary expander; M, male; and F, female. Values are expressed as means ± standard deviations.

†† P < .001.

Figure 1. Two types of expander designs used in the study: (1) Tooth bone-borne maxillary expander (MSE) before treatment (A) and after expansion (B); (2) Tissue bone-borne maxillary expander (C-expander) before treatment (C) and after expansion (D).
tions were also evaluated on the same axial slices (Figure 3D). It was impossible to measure the data using blind methods because the appliance was inevitably shown in the CBCT images.

Elicitation of Pure Alveolar Bone Bending

Maxillary expansion pattern can be divided into naso-maxillary complex (NMC) rotation, alveolar bone bending, and tooth tipping. Previous studies\(^1\) had demonstrated that if maxillary bone was separated successfully by RME, the NMC split transversely in a pyramidal-like configuration in coronal sections, and the center of rotation was the frontonasal suture (FNS).\(^2\) This pyramidal pattern of NMC rotation inevitably accompanies alveolar bone inclination change as a part of the rotation arm. Additionally, there could be pure alveolar bone inclination change by itself through remodeling or bending. To calculate NMC rotation (\(\Theta\)), the inverse tangent function was used. The triangle base was the distance from the FNS to the nasal floor, and the height of the triangle was half of the skeletal expansion at the nasal floor level (Figure 4).

Pure alveolar bone bending itself was presumed by calculating the experimental measurement of alveolar inclination change minus the amounts of NMC rotation (\(\Theta\)). Skeletal expansion by NMC rotation at the crown level was presumed by measuring the proportion of the distance from the center of rotation to the nasal floor and the distance from the center of rotation to the central fossa.

By comparing this calculated skeletal expansion at the crown level and measured dental expansion at the crown level, the pure dentoalveolar expansion resulting from alveolar bending itself and tooth tipping was revealed.

Statistical Analysis

Normality of the data distribution was confirmed using the Shapiro-Wilk test. To determine intraexaminer reproducibility, the same examiner repeated all measurements after 2 weeks. The resultant intraclass correlation coefficient (ICC) indicated high reliability (ICC > 0.90). A paired \(t\)-test was done for comparison between the T1 and T2 stages in each group, and an independent \(t\)-test was performed to compare the mean differences between the two groups. To compare the qualitative variables—total emergence numbers of dehiscences and fenestrations—Pearson’s chi-square and Fisher’s exact tests were done. Spearman correlation analysis was performed to evaluate the associations among buccal bone changes, dentoalveolar conditions, and initial age. All statistical analyses were performed using SPSS version 22.0 software (SPSS Inc, Chicago, Ill).
RESULTS

Comparison Between MSE and C-Expander (Table 2; Figure 5)

Both groups had greater dental expansion at the crown level than skeletal maxillary expansion at the nasal floor level. The MSE group showed greater statistically significant increases in dental expansion than did the C-expander group (0.90 mm, \(P < .05\)), but no significant difference was noted in skeletal expansion (\(P = .859\)).

Angular changes of the buccal alveolar bone and tooth axes were significantly different between the two groups. The C-expander group showed greater buccal tipping of the alveolus than did the MSE group (\(P < .01\)). Tooth inclination was affected only in the MSE group (2.77° right and 2.03° left), whereas the C-expander group showed no significant changes (\(P > .05\)).

Right and left buccal alveolar bone height decreased in the MSE group by 1.15 ± 1.75 mm (\(P < .01\)) and 1.51 ± 1.84 mm (\(P < .01\)), respectively. The C-expander group had no statistically significant changes in the left alveolar height, and a slight decrease of 0.13 ± 0.29 mm was observed for the left alveolar height (\(P = .041\)). Right and left buccal alveolar bone thickness decreases in the MSE group were −0.67 ± 0.44 mm (\(P < .001\)) and −0.48 ± 0.48 mm (\(P < .001\)), respectively. However, in the C-expander group, there was no significant change in buccal alveolar bone thickness (\(P > .05\)).

Buccal bone dehiscences were significantly more likely to be present in the MSE group than in the C-expander group (\(P < .01\), MSE: 15, C-expander: 2). There was no significant difference between the two groups.

Figure 3. Definition of measurements (A) NF, nasal floor expansion; CR, crown expansion. (B) TI, tooth inclination; AI, alveolar inclination: (C) BH, buccal alveolar bone height loss: (D) BT, buccal alveolar bone thickness.
Figure 4. (A) Pyramidal-like configuration of nasomaxillary complex separation. (B) Triangular illustration of NMC separation. Vertex is the frontonasal suture, which is the center of rotation, and half of the acute angle is NMC rotation ($\theta$). The height of the triangle is the distance from the center of rotation to the nasal floor ($h_1$) and the distance from the center of rotation to the central fossa ($h_2$). The base of the triangle is maxillary expansion at the nasal floor level ($b_1$) and central fossa level ($b_2$).

Table 2. The Immediate Changes After Maxillary Expansion with MSE or C-Expander Appliance

<table>
<thead>
<tr>
<th></th>
<th>MSE T1–T2</th>
<th>C-Expander T1–T2</th>
<th>Group 1–Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Expansion, mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Nasal floor (NF)</td>
<td>2.45</td>
<td>1.37</td>
<td>2.38</td>
</tr>
<tr>
<td>2. Crown (CR)</td>
<td>4.91</td>
<td>1.50</td>
<td>4.01</td>
</tr>
<tr>
<td>Alveolar inclination, °</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Right (AlR)</td>
<td>0.74</td>
<td>1.19</td>
<td>2.18</td>
</tr>
<tr>
<td>4. Left (AlL)</td>
<td>0.88</td>
<td>1.28</td>
<td>2.35</td>
</tr>
<tr>
<td>Tooth inclination, °</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Right (TIr)</td>
<td>2.77</td>
<td>2.38</td>
<td>0.10</td>
</tr>
<tr>
<td>6. Left (TIL)</td>
<td>2.03</td>
<td>2.20</td>
<td>0.03</td>
</tr>
<tr>
<td>Buccal bone height loss, mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Right (BHR)</td>
<td>1.15</td>
<td>1.75</td>
<td>0.13</td>
</tr>
<tr>
<td>8. Left (BHL)</td>
<td>1.51</td>
<td>1.84</td>
<td>0.03</td>
</tr>
<tr>
<td>Buccal bone thickness, mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Right (BTR)</td>
<td>-0.67</td>
<td>0.44</td>
<td>-0.13</td>
</tr>
<tr>
<td>10. Left (BIT)</td>
<td>-0.48</td>
<td>0.48</td>
<td>-0.01</td>
</tr>
<tr>
<td>Buccal bone defects.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Dehiscence (DE)</td>
<td>15</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>12. Fenestration (FE)</td>
<td>6</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

* Paired t-test was done for intragroup comparison.
† Independent t-test was done for intergroup comparison. T1–T2 indicates difference between before treatment (T1) and 3 months after expansion (T2). Mean difference = (MSE) – (C-Expander). $\phi_1$, $\phi_2$; indicate Total emergence number; Pearson’s chi-square test was done for intergroup comparison.
* P < .05; † P < .01; †† P < .001.
groups for frequency of fenestration ($P = .111$, MSE: 6; C-expander: 1).

**Elicitation of Pure Alveolar Bone Bending (Table 3)**

Both groups showed similar NMC rotation in coronal sections (MSE: 1.03°; C-expander: 1.04°). The amount of pure alveolar bone bending was close to zero in the MSE group (−0.22°). However, in the C-expander group, pure alveolar bone bending was greater than NMC rotation (1.22°). Pure skeletal expansion at the crown level, which was calculated from the proportional equation, were similar in both groups (MSE: 3.26 mm; C-expander: 3.23 mm), but pure dentoalveolar expansion at the crown level was greater in the MSE group (1.65 mm) than in the C-expander group (0.78 mm).

**Correlations Between Initial Conditions and Buccal Bone Changes (Table 4)**

Buccal alveolar bone height loss in the MSE group showed a negative relationship with initial buccal alveolar bone thickness ($r = 0.43, P < .01$) and a positive relationship with patient initial age ($r = 0.37, P < .01$). On the contrary, buccal alveolar bone height loss had no statistically significant relationship

<table>
<thead>
<tr>
<th>Table 3. Elicitation of Pure Alveolar Bone Bending Through Analysis on Pyramid-Like Configuration of Nasomaxillary Complex (NMC) Expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measured value</strong></td>
</tr>
</tbody>
</table>
| Expansion, mm
  ① Nasal floor (NF) | 2.45 | 1.37 | .000†† |
  ② Crown (CR) | 4.91 | 1.50 | .000†† |
| Radius of NMC rotation, mm
  ① Nasal floor level | 68.21 | 7.35 | |
  ② Crown level | 90.63 | 4.84 | |
| Alveolar inclination (Al), ° |
  ⑤ | 0.81 | 1.22 | .000†† |
| **Calculated value** |
| Rotation, °
  ⑥ NMC rotation (θ) | 1.03 | |
  ⑦ Pure alveolar bending (c−c′) | −0.22 | |
| Expansion at crown level, mm
  ⑧ Pure skeletal (NMC) expansion(CR′) | 3.26 | |
  ⑨ Pure dentoalveolar expansion (c−c′) | 1.65 | |

*Paired t-test was done for intragroup comparison. 
① indicates distance in sagittal plane between fronto-maxillary suture to nasal floor level of the first molar; ②, distance in sagittal plane between fronto-maxillary suture to central fossa level of the first molar; and ⑤, $\theta = \tan^{-1} [\frac{c′−c}{2×c′c}];$
⑥, $CR′ = c_1×[c_2/3];$.
†† $P < .001.$

---

*Figure 5. The immediate changes after maxillary expansion. (A) MSE (a, nasal floor expansion; b, crown expansion; c, alveolar bending; c′, pure alveolar bending; d, tooth tipping; e, buccal alveolar bone height loss; f, buccal alveolar bone thickness at the furcation level). (B) C-expander (a, nasal floor expansion; b, crown expansion; c, alveolar bending; c′, pure alveolar bending; d, tooth tipping; e, buccal alveolar bone height loss; f, buccal alveolar bone thickness at the furcation level).*
with initial conditions in the C-expander group. Buccal alveolar bone thickness change had no statistically significant relationship with initial conditions in either group. The MSE group also showed a statistically significant positive relationship between buccal alveolar bone height loss and initial tooth inclination ($r = 0.29$, $P < .05$).

**DISCUSSION**

The amount of maxillary skeletal expansion using the two types of expanders investigated was not statistically different in this study (MSE: 2.45 mm; C-expander: 2.38 mm, $P = .859$). Previous studies also reported similar amounts of skeletal expansion using a miniscrew-assisted RPE (2.11–2.6 mm) compared with the current study. Dentoalveolar expansion was greater in the tooth bone-borne type expander (MSE: 4.91 mm; C-expander: 4.01 mm). A similar trend was noted in other studies.

Molar inclination increased in the MSE group but not with the C-expander. A tooth bone-borne expander caused similar amounts of buccoversion of the anchorage teeth in a recent study. For the MSE group, the stress builds up in the hard tissue of the anchor teeth and the hard palate. The gap between the screw (1.5 mm in diameter) and holes (2.0 mm in diameter) allows the initial activation of the expander to loading of the anchor teeth primarily, although the suture is not open. This could be a reason for the tipping of anchorage teeth that was observed. However, some patients in the MSE group skipped 1 day of activation when the stress was too excessive (there was a risk that the turning instrument would break). In the C-expander group, the expansion force was distributed to the palatal tissue and the basal bone.

Similar results were reported in bone-borne expander studies.

Alveolar buccal inclination was greater in the C-expander group. This inclination change included lateral rotation of the NMC. To evaluate pure alveolar bending, NMC rotation was deducted from the alveolar inclination change (Table 3). Buccal alveolar bending was found to occur only in the C-expander group (1.4°). In the MSE group, the alveolus was palatally uprighted at about 0.2°. However, this was not a measured value but rather a predictive value not verified by the statistical method. The increase in palatal angulation was dominant in the Hyrax, not the Haas, expander. However, in that previous study, palatal soft tissue morphologic change was measured using 3D cast modeling, so there was a possibility of soft tissue deformation by the acrylic resin pad. In the present study, by measuring the inclination of palatal cortical bone of the alveolus with CBCT sectional images, a pure alveolar bony effect was noted. The lateral force applied to the palatal tissue by the C-expander without banded anchorage teeth is presumed to remodel the alveolar bone. More definitive mechanisms of the alveolar inclination change should be evaluated in a further study. The present study was meaningful for separating the three components of total expansion (skeletal, alveolar, dental). Though there was no significant difference between the two groups in skeletal expansion, the other two components did show differences. According to the tooth inclination changes and pure alveolar bending (Tables 2 and 3), the amount of dentoalveolar expansion (1.65 mm) was mainly due to tooth movement in the MSE group, and the amount of dentoalveolar expansion (0.78 mm) was contributed by alveolar bending in the C-expander group.

Many studies of the Hyrax appliance, including the tooth bone-borne expander, suggested thinning of buccal bone around anchorage teeth after RME (0.6–1.24 mm). In the current study, the MSE group had a similar decrease in buccal bone thickness (0.48–0.67 mm). There have been conflicting results regarding changes in buccal bone thickness during retention, including decreased buccal bone thickness after 6 months of retention,31 buccal bone remodeling after 6 months of retention,32 and no correlation between buccal bone loss and retention time.38 Considering that buccal bone thickness of the first molar was 0.8–1.9 mm in previous studies and 1.8 mm in the current study, the amount of thinning in the MSE group might be clinically acceptable. On the other hand, the C-expander showed no significant change of buccal bone thickness. This was consistent with buccal bone height change and the incidence of bone defects detected. Buccal bone height loss in a previous study with the tooth bone-borne expander was 1.7 mm, which was in agreement with the MSE group in the current study. In the C-expander, buccal bone height loss was less than 0.13 mm. Even in prepubertal patients, alveolar height loss with RME could result in development of a dehiscence.
buccal bone dehiscence was significantly higher with MSE than with the C-expander. The incidence ratio was 31.3% (15/48) in MSE, compared to 4.2% (2/48) in the C-expander.

Some variables had significant correlations to buccal bone changes. In the MSE group, age, initial buccal bone thickness, and initial molar inclination had significant correlations to buccal bone height change ($r=0.37$, $P<.01$; $r=-0.43$, $P<.01$; and $r=0.29$, $P<.05$, respectively). This can be interpreted as a higher probability for buccal bone dehiscence after tooth-borne-bone expansion in older patients, or in patients with thinner buccal bone plates, or in those with more buccal molar inclination pretreatment.

For transverse discrepancy patients, tipping of the teeth is a particular concern because of an already-compensated maxillary dentition. Therefore, the correlation between tipped molars and buccal bone changes in the present study is relevant to the periodontal prognosis following maxillary expansion treatment. Some tooth-borne-expander studies in adolescent patients reported similar significant correlations among age, initial buccal bone thickness, and buccal bone changes, with specific sensitivity in subjects with thinner buccal bone plates and RME-induced bone dehiscences on the buccal of anchorage teeth. On the other hand, in the C-expander group, age and initial dentoalveolar conditions had no significant correlation to buccal bone changes ($P>.05$). This might be because following tissue-borne-bone anchored expansion there was less tooth movement, and most of the transverse expansion occurred via NMC rotation and alveolar bone bending. So for the patient with poor periodontal support, the tissue bone-borne expander would be preferred rather than the tooth-borne-bone expander.

**CONCLUSIONS**

- Skeletal expansion was similar in the MSE and C-expander groups.
- Dentoalveolar expansion was more than twice as great in the MSE group than in the C-expander group. Pure alveolar bone bending appears to be the main cause of dentoalveolar expansion with the C-expander, whereas tipping of the anchorage teeth seems to be the main cause with the MSE.
- Decreases in buccal alveolar bone height and thickness as well as the occurrence of bone defects were greater in the MSE group.
- In the MSE group, age and initial buccal alveolar bone thickness had moderate correlations with buccal alveolar bone height loss, whereas the C-expander group reflected no significant correlations.
- For the patient with vulnerable periodontal conditions or older age, the tissue bone-borne maxillary expander could be the more conservative treatment option.

**REFERENCES**


