NiTi Expansion in Operated Unilateral Cleft Palate Patients

KY Poornima

ABSTRACT

Objective: To evaluate the efficacy of nickel-titanium expander for maxillary expansion and the skeletal and dental changes associated with the expander in operated cleft palate patients.

Materials and methods: Ten male unilateral cleft lip and palate patients in the age group of 9 to 13 years with transverse maxillary deficiency and with no history of bone grafting procedure, were selected from the patients visiting the combined cleft lip and palate clinic/orthodontic clinic.

Results: Orthopedic expansion of maxillary segments ranged from 2 to 5 mm, constituted 25% of total expansion. Maxillary intermolar width measured at cuspal tips and palatal gingival margins (T-16, 26 and G-16, 26) increased by a mean of 8.6 mm (p < 0.001) and 5.4 mm (p < 0.001). Maxillary intercanine width measured at cuspal tips and palatal gingival margins (T-13, 23 and G-13, 23) increased by a mean of 4.3 mm (p < 0.01) and 3.38 mm (p < 0.01). Postexpansion changes measured on the mandibular dental casts showed insignificant changes except in the intermolar area. Mandibular intermolar width measured at cuspal tips and lingual gingival margins (T-36, 46 and G-36, 46) increased by a mean of 0.6 mm (p < 0.05). The dental expansion constituted for 75% total expansion. Mandibular, occlusal plane angles increased by 2 to 3° resulting in increased TAFH.

Conclusion: NiTi expansion in operated cleft patients, showed mainly orthodontic expansion. The significant change in the maxillary intermolar region is due to the direct placement of NiTi palatal expander to 16, 26.

Keywords: Cleft lip and palate, Maxillary expansion, Nickel-titanium palatal expander.

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INTRODUCTION

Successful cleft lip and palate rehabilitation requires an interdisciplinary approach. Many of the orthodontic problems of children with cleft palate, result not only from the cleft itself, but also from the effects of surgical repair. Though early surgical intervention of cleft palate improves the patient’s quality of life, it also tends to constrict the maxilla and contributes to anterior and posterior crossbite to a varying degree. Maxillary expansion is a procedure that is used by orthodontists to correct absolute or relative maxillomandibular buccolingual discrepancies. The prime objective of maxillary expansion is to coordinate the maxillary and mandibular bases. Expansion of narrow or collapsed maxillary arches can be achieved through orthodontic and orthopedic movements or combination of both. The orthodontic and orthopedic forces often differ in terms of objectives, application, intensity, time, timing and type of force.

Most rapid as well as slow maxillary expanders are successful, but require extensive laboratory procedures and frequent adjustments, may cause discomfort while wearing and are incapable of correcting the molar rotations. To overcome the limitations of the conventional appliances, Wendell V Arndt introduced a tandem loop, temperature activated nickel-titanium palatal expander (NiTi expander). The efficacy of NiTi expander for maxillary expansion has been reported in the literature in many small series but not systematically evaluated, especially in cleft palate patients. The present study was undertaken to evaluate the efficacy of nickel-titanium expander for maxillary expansion and the skeletal and dental changes associated with the expander in operated cleft palate patients.

MATERIALS AND METHODS

Ten males with unilateral cleft palate with or without lip anomaly, in the age group of 9 to 13 years were selected, from the patients visiting the combined cleft lip and palate clinic/orthodontic clinic. Only male patients were selected, as the prevalence of cleft palate incidence ratio in males and females is 2:1.

Sample Selection Criteria

Inclusion Criteria

Ten males with unilateral cleft lip and palate patients with transverse maxillary deficiency who had undergone surgical repair of cleft palate with or without lip repair (CP ± L).
Exclusion Criteria

Unilateral cleft palate patients who underwent bone grafting and who had previous history of major orthodontic treatment were excluded from the study.

After the case selection, a detailed clinical history, lateral and posteroanterior cephalograms of the skull with teeth in occlusion, upper and lower alginate impressions for study models and photographs were taken. The photographic records included, front and lateral profile views, intraoral (right and left lateral views), and occlusal views.

Nickel-Titanium Expander Size Selection and Placement\(^4,6\) (Fig. 1)

The required expansion was estimated as follows:

1. Maxillary arch width was measured between the central pits of permanent maxillary first molars, i.e. 16, 26 while the mandibular arch width was measured between the distobuccal cusp tips of permanent mandibular first molars, i.e. 36, 46. The difference between these two measurements was taken as the amount of expansion that was required.

2. Distance between the lingual grooves of 16, 26 was measured towards the gingival side. This value was added to the amount of expansion required, and 2 mm of over correction was added to compensate for the combined widths of band material and the lingual sheaths as proposed by Wendell V Arndt.\(^5\) The total was taken as the nickel-titanium expander size.

Nickel-titanium expanders come in eight different intermolar widths sizes ranging from 26 mm to 47 mm as No. 26, 29, 33, 35, 38, 41, 44, and 47 and generate forces of 180 to 300 gm. When a size falls in between the numbers then the higher side number is selected. Few patients with severe constriction of maxilla required multiple sizes of expander as the exact size placement was not possible. In such cases lower number to higher number expanders were placed depending on the amount of expansion achieved.

Placement of Nickel-Titanium Expander

After the selection of appropriate nickel-titanium palatal expander size, the permanent maxillary first molars were banded in each case and the lingual sheaths were welded and soldered to each band. The molar bands were then cemented with Fuji II Glass Ionomer luting cement. Nickel-titanium expander was cooled with ice and the martensitic form was inserted into the bands as one passive unit. The occlusal surface of the permanent mandibular first molars was raised by Glass ionomer filling to provide occlusal clearance. Each case was reviewed after 24 hours of expander placement, then at six weeks interval till the end of study period (3 months), and the postexpansion records were taken after 3 months of expansion treatment (Figs 2 to 4).
Cephalometric Analysis

Cephalometric analysis was carried out using posteroanterior (PA) and lateral cephalograms (Figs 5 and 6). All the cephalograms were taken with the patients in the standing position with teeth in occlusion and lips in unstrained position. Both pre- and postcephalograms were taken on the same cephalostat to eliminate the need for correction of radiographic magnification. The cephalograms were traced manually and the landmarks were identified and marked with a single dot by a single operator.

Reference planes: Following reference planes were used in the study:

1. Horizontal reference plane (HRP) was constructed between the right and left latero-orbital points. This reference plane was used for measuring angular parameters on PA cephalogram.

2. Constructed FH plane was drawn with an inferior angle of 7° to SN plane through point ‘S’. The constructed FH plane was denoted by FH. This plane was used to measure the vertical linear measurements.

3. The FH perpendicular plane was constructed perpendicular to FH plane through point ‘S’ and denoted by SFH. This plane was used to measure the horizontal linear measurements.

Cast Analysis

For convenience, FDI notation was used to represent the tooth nomenclature.

Maxillary Arch

The distance between the deepest points on the palatal gingival margins of 13 to 23, 14 to 24 and 16 to 26 (herein after G-13, 23; G-14, 24; G-16, 26) and between the cusp tips of 13 to 23, 14 to 24 and 16 to 26 (herein after T-13, 23; T-14, 24; T-16, 26). When the 13 to 23 had not erupted and the deciduous canines were retained then measurements on 53 to 63 were taken.

Mandibular Arch

The distance between the deepest points on the lingual gingival margins of 33 to 43, 34 to 44 and 36 to 46 (herein after G-33, 43; G-34, 44; G-36, 46) and between the cusp tips of 33 to 43, 34 to 44 and 36 to 46 (herein after T-33, 43; T-34, 44; T-36, 46). When 33, 43 had not erupted and the deciduous canines were retained, the measurements were made on 73, 83.

Statistical Analysis

The measured pre- and postexpansion treatment values of the cephalometric and dental cast analysis were fed in to the computer in a master file, created under excel. The data obtained was analyzed statistically using SPSS 7.5 statistical software. The data was subjected to descriptive analysis for mean and standard deviation for all the variables. To compare the pre- and postexpansion changes, student paired t-test was employed for each variable.

Measurement of Error and Coefficient of Reliability

To avoid the error due to fatigue, only a limited number of cephalograms were digitized in one sitting. The intrainvestigator error was calculated by digitizing 6 randomly selected cephalograms on a separate occasion.

Dahlberg formula was used to calculate the error.

\[
Se = \sqrt{\frac{\sum (d \times d)}{2n}}
\]

where

d = Difference between 1st and 2nd readings.

n = Number of cephalograms digitized.

The intrainvestigator error for the linear measurements was 0.4 and that for the angular measurements was 0.681 (Table 1). The coefficient of reliability was calculated according to the concept given by Midtgard et al8 (Table 2). They suggested that ideally the error of variance should be less than 3 percent.
The error of variance was calculated to the formula:

\[
EV = \sqrt{\frac{EM^2 \times 100}{SD^2}}
\]

where

- \( EV \) = Error of variance
- \( EM \) = Error of measurement
- \( SD \) = Standard deviation

Standard deviation was calculated as:

\[
SD = \sqrt{\frac{\sum X^2 - \frac{\sum X \times \sum X}{n}}{n-1}}
\]

Where \( X \) = mean error.

The values obtained by calculating the variance error and coefficient of reliability were within normal limits, they were not considered during statistical analysis.

### RESULTS

**PA Cephalogram: Linear and Angular Measurements (Tables 3 and 4)**

Nitinol expansion of collapsed maxilla did not show significant changes in the lower nasal width, interzygomatic width and in the bigonial widths. However, basal maxillary width (MaxW) changed significantly from mean 64.1 ± 4.86 mm to 66.5 ± 4.40 mm \((p < 0.01)\). Upper intermolar width (UImolW) increased from mean 52.8 ± 5.81 mm to 60.2 ± 5.20 mm, which was highly significant statistically \((p < 0.001)\). Lower intermolar width (LimolW) increased from mean 57.0 ± 5.88 mm to 58.7 ± 5.62 mm, which was statistically significant \((p < 0.01)\).
Table 4: Pre- and postexpansion angular measurements on PA cephalogram (n = 10)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Variable</th>
<th>Pretreatment Mean ± SD</th>
<th>Posttreatment Mean ± SD</th>
<th>Difference Mean ± SD</th>
<th>p-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Bmaxr</td>
<td>77.8 ± 2.44</td>
<td>78.2 ± 2.65</td>
<td>0.4 ± 0.69</td>
<td>0.10</td>
<td>NS</td>
</tr>
<tr>
<td>2.</td>
<td>Bmaxl</td>
<td>76.0 ± 5.01</td>
<td>76.8 ± 5.29</td>
<td>0.6 ± 1.07</td>
<td>0.11</td>
<td>NS</td>
</tr>
<tr>
<td>3.</td>
<td>Umolr</td>
<td>75.4 ± 2.11</td>
<td>79.5 ± 2.67</td>
<td>4.1 ± 0.87</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>4.</td>
<td>Umoll</td>
<td>73.1 ± 2.59</td>
<td>78.1 ± 2.55</td>
<td>5.0 ± 1.17</td>
<td>0.000</td>
<td>***</td>
</tr>
</tbody>
</table>

*p < 0.05; **p < 0.01; ***p < 0.001; NS: Nonsignificant

Table 5: Pre- and postexpansion angular measurements on lateral cephalogram (n = 10)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Variable</th>
<th>Pretreatment Mean ± SD</th>
<th>Posttreatment Mean ± SD</th>
<th>Difference Mean ± SD</th>
<th>p-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>SNA</td>
<td>78.1 ± 4.79</td>
<td>79.4 ± 4.76</td>
<td>1.3 ± 0.95</td>
<td>0.002</td>
<td>**</td>
</tr>
<tr>
<td>2.</td>
<td>SNB</td>
<td>75.9 ± 3.78</td>
<td>76.4 ± 3.68</td>
<td>0.5 ± 0.53</td>
<td>0.015</td>
<td>*</td>
</tr>
<tr>
<td>3.</td>
<td>ANB</td>
<td>2.2 ± 4.02</td>
<td>3.0 ± 4.29</td>
<td>0.8 ± 0.92</td>
<td>0.022</td>
<td>*</td>
</tr>
<tr>
<td>4.</td>
<td>FMA</td>
<td>24.7 ± 4.35</td>
<td>26.9 ± 4.38</td>
<td>2.2 ± 1.32</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>5.</td>
<td>SN-GoGn</td>
<td>31.1 ± 4.63</td>
<td>33.1 ± 4.70</td>
<td>2.0 ± 1.05</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>6.</td>
<td>SN-OP</td>
<td>16.4 ± 3.66</td>
<td>19.3 ± 3.80</td>
<td>3.0 ± 1.52</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>7.</td>
<td>U1-SN</td>
<td>77.5 ± 7.38</td>
<td>79.5 ± 7.99</td>
<td>2.0 ± 1.49</td>
<td>0.002</td>
<td>**</td>
</tr>
</tbody>
</table>

*p < 0.05; **p < 0.01; ***p < 0.001; NS: Nonsignificant

SNA increased from a mean of 78.1° ± 4.79° to 79.4° ± 4.76° (p < 0.01). SNB increased from mean 75.9° ± 3.78° to 76.4° ± 3.68° (p < 0.05). ANB increased from a mean of 2.2° ± 4.02° to 3.0° ± 4.29° (p < 0.05). FMA changed significantly from a mean 24.7 ± 4.35° to 27 ± 4.38° (p < 0.001). SN-GoGn angle increased significantly from a mean of 31 ± 4.63° to 33.1 ± 4.70° (p < 0.001). SN-OP angle increased significantly from a mean of 16.4 ± 3.66° to 19.3 ± 3.80° (p < 0.001). SN-PP angle did not show any change during the expansion. Upper incisor to SN plane angulation increased by a mean of 2 ± 1.49° (p < 0.01).

The perpendicular distances measured from points PNS and ANS to FH plane increased by a mean of 2 ± 2.21 mm and 1.3 ± 1.34 mm (p < 0.05), respectively. Total anterior facial height (N-Me) and total posterior facial height (S-Go) increased significantly from mean 112.9 ± 9.77 mm to 117 ± 9.14 mm and from mean 73.6 ± 5.96 mm to 75.1 ± 5.15 mm respectively (p < 0.05). The linear distance measured from the tip of the upper incisor TU1 to SFH plane increased by a mean of 1.6 ± 0.07 mm (p < 0.01) and from the tip of the mesiobuccal cusp of maxillary molar TUM1 to SFH plane decreased by a mean of −1.5 ± 1.31 mm (p < 0.05). A- SFH increased from 64.2 ± 5.77 to 66.1 ± 6.72 (p < 0.05).

Table 6: Pre- and postexpansion linear measurements on lateral cephalogram (n = 10)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Variable</th>
<th>Pretreatment Mean ± SD</th>
<th>Posttreatment Mean ± SD</th>
<th>Difference Mean ± SD</th>
<th>p-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>PNS-FH</td>
<td>39.7 ± 4.71</td>
<td>41.7 ± 4.57</td>
<td>2.0 ± 2.21</td>
<td>0.019</td>
<td>*</td>
</tr>
<tr>
<td>2.</td>
<td>ANS-FH</td>
<td>40.8 ± 6.90</td>
<td>42.1 ± 7.12</td>
<td>1.3 ± 1.34</td>
<td>0.013</td>
<td>*</td>
</tr>
<tr>
<td>3.</td>
<td>A-SFH</td>
<td>64.2 ± 5.77</td>
<td>66.1 ± 6.72</td>
<td>1.9 ± 1.97</td>
<td>0.014</td>
<td>*</td>
</tr>
<tr>
<td>4.</td>
<td>N-Me</td>
<td>112.9 ± 9.77</td>
<td>117.2 ± 9.14</td>
<td>4.3 ± 4.19</td>
<td>0.010</td>
<td>*</td>
</tr>
<tr>
<td>5.</td>
<td>S-Go</td>
<td>73.6 ± 5.96</td>
<td>75.1 ± 5.15</td>
<td>1.5 ± 1.58</td>
<td>0.015</td>
<td>*</td>
</tr>
<tr>
<td>6.</td>
<td>TU1-SFH</td>
<td>59.9 ± 5.70</td>
<td>61.5 ± 5.66</td>
<td>1.6 ± 1.07</td>
<td>0.002</td>
<td>**</td>
</tr>
<tr>
<td>7.</td>
<td>TUM1-SFH</td>
<td>34.0 ± 3.46</td>
<td>32.5 ± 5.50</td>
<td>−1.5 ± 1.31</td>
<td>0.013</td>
<td>*</td>
</tr>
</tbody>
</table>

*p < 0.05; **p < 0.01; NS: Nonsignificant

Lateral Cephalogram: Angular and Linear Measurements (Tables 5 and 6)

Maxillary and Mandibular Dental Casts (Tables 7 and 8)

Maxillary intercanine width measured at the cusp tips and at the palatogingival margins showed significant changes. T-13, 23 increased from 17.2 ± 11.31 to 21.6 ± 12.52 (p < 0.01), whereas G-13, 23 increased from 14.2 ± 9.00 to 17.4 ± 9.73 (p < 0.01). Maxillary intermolar width measured at T-14, 24 or T-54, 64 increased from 30.3 ± 5.55 to 35.8 ± 3.38, whereas at G-14, 24 or G-54, 64 increased from 18.0 ± 4.52 to 22.7 ± 2.80 (p < 0.001) intermolar change measured at T-16, 26 increased from 44.0 ± 5.86 to 52.8 ± 5.57 and at G-16, 26 increased from 31.4 ± 3.62 to 36.5 ± 4.13 (p < 0.001). Post expansion changes measured on the mandibular dental casts showed insignificant changes except in the intermolar area. T-36, 46 increased from 45.6 ± 4.42 to 46.2 ± 4.77 and at G-36, 46 increased from 33.1 ± 3.07 to 33.8 ± 2.74 (p < 0.05).
DISCUSSION

PA Cephalogram

Linear Changes during Expansion

In the present study, the LNasW, ZyW, GoW did not show significant change with the expansion treatment. However BMaxW, increased by a mean of 2.5 mm (p < 0.01) and UmolW increased by a mean of 7.4 mm (p < 0.001). The skeletal response constituted for 25% of total expansion. This is in accordance with the study of Krebs and Hicks. Out of 23 subjects treated with RME, 6 children of Krebs’ sample within 10 to 12 years of age, showed mean skeletal separation of 3.6 mm (45 percent of total expansion) with a mean increase in the dental arch width of 8.0 mm. Hicks on 5 children treated with the SME for an average time of 8 to 13 weeks showed a mean skeletal increase of 2 mm, which constituted for 28% of total expansion, with a mean increase in the dental arch width of 7.1 mm. Where as Frank and Engel in their sample of 20 subjects in the age group 10 years 3 months treated with quad-helix appliance showed a mean skeletal increase of 2 mm, which constituted for 28% of total expansion, with a mean increase in the dental arch width of 7.1 mm. Where as Frank and Engel in their sample of 20 subjects in the age group 10 years 3 months treated with quad-helix appliance showed a mean increase in maxillary width of 0.92 mm, with a mean increase in the UmolW of 5.88 mm. In the present study LimolW increased by a mean of 1.7 mm (p < 0.01). This can be explained by the fact that, when the cross bite gets corrected to normal occlusion, the buccal inclines of the palatal cusps of the maxillary teeth move directly in contact with the lingual inclines of the bucual cusps of the mandibular teeth. These same occlusal forces accounted for the small increase in the LimolW of 1.7 mm. However, Frank and Engel reported no change in the LimolW during maxillary expansion with the quad-helix appliance.

In the present study, the skeletal expansion accounted for 25% of the total expansion due to the resistance offered by the facial skeleton. Isaacson and Murphy in their study on CP + L patients at 12 years of age with RME procedure reported that the resistance of the facial skeleton is, as important as the midpalatal suture for the end result. Timms in his study on noncleft patients explained that, the main resistance to midpalatal suture opening is probably not in the suture itself, but in the surrounding structures, particularly the sphenoid and the zygomatic bones.

Angular Changes during Expansion

The maxilla is anatomically connected to the rest of the craniofacial skeleton at points superior to the level at which its two halves join each other at the midpalatal suture. Force application for palatal expansion is, for reasons of accessibility, in the inferior most portion of the bone. Consequently, tipping of the two maxillae is expected.

In the present study, Bmaxr, Bmaxl angles increased by a mean of 0.4° and 0.6° respectively, but are statistically non significant. When these angular changes are correlated with the linear changes, conclusion can be drawn that the skeletal expansion even though less, is solely due to the translatory movement of the two halves of the maxillae. However, Umolr, Umoll increased significantly by a mean of 4.1° and 5° indicating molar tipping during expansion (p < 0.001).

Many of the studies failed in defining and relating the dental and skeletal linear changes to angular changes. Isaacson and Murphy in their study on CP ± L patients with RME procedure reported that the resistance of the facial skeleton is, as important as the midpalatal suture for the end result. Timms in his study on noncleft patients explained that, the main resistance to midpalatal suture opening is probably not in the suture itself, but in the surrounding structures, particularly the sphenoid and the zygomatic bones.

Table 7: Pre- and postexpansion changes on maxillary dental casts (n = 10)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Variable</th>
<th>Pretreatment Mean ± SD</th>
<th>Posttreatment Mean ± SD</th>
<th>Difference Mean ± SD</th>
<th>p-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T-13, 23</td>
<td>17.2 ± 11.31</td>
<td>21.6 ± 12.52</td>
<td>4.3 ± 3.89</td>
<td>0.004</td>
<td>**</td>
</tr>
<tr>
<td>2.</td>
<td>G-13, 23</td>
<td>14.2 ± 9.00</td>
<td>17.4 ± 9.73</td>
<td>3.4 ± 2.97</td>
<td>0.007</td>
<td>**</td>
</tr>
<tr>
<td>3.</td>
<td>T-14, 24</td>
<td>30.3 ± 5.55</td>
<td>35.8 ± 3.38</td>
<td>5.6 ± 3.26</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>4.</td>
<td>G-14, 24</td>
<td>18.0 ± 4.52</td>
<td>22.7 ± 2.80</td>
<td>4.7 ± 2.59</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>5.</td>
<td>T-16, 26</td>
<td>44.0 ± 5.86</td>
<td>52.8 ± 5.57</td>
<td>8.6 ± 2.29</td>
<td>0.000</td>
<td>***</td>
</tr>
<tr>
<td>6.</td>
<td>G-16, 26</td>
<td>31.4 ± 3.62</td>
<td>36.5 ± 4.13</td>
<td>5.4 ± 2.18</td>
<td>0.000</td>
<td>***</td>
</tr>
</tbody>
</table>

**p < 0.01; ***p < 0.001; NS: Nonsignificant

Table 8: Pre- and postexpansion changes on mandibular dental casts (n = 10)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Variable</th>
<th>Pretreatment Mean ± SD</th>
<th>Posttreatment Mean ± SD</th>
<th>Difference Mean ± SD</th>
<th>p-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>T-33, 43</td>
<td>24.5 ± 2.36</td>
<td>24.5 ± 2.24</td>
<td>0.0 ± 0.15</td>
<td>0.343</td>
<td>NS</td>
</tr>
<tr>
<td>2.</td>
<td>G-33, 43</td>
<td>19.1 ± 2.55</td>
<td>19.6 ± 2.22</td>
<td>0.5 ± 0.52</td>
<td>0.031</td>
<td>NS</td>
</tr>
<tr>
<td>3.</td>
<td>T-34, 44</td>
<td>30.9 ± 4.99</td>
<td>31.2 ± 4.91</td>
<td>0.3 ± 0.48</td>
<td>0.081</td>
<td>NS</td>
</tr>
<tr>
<td>4.</td>
<td>G-34, 44</td>
<td>24.7 ± 4.05</td>
<td>25.1 ± 3.75</td>
<td>0.4 ± 0.40</td>
<td>0.046</td>
<td>NS</td>
</tr>
<tr>
<td>5.</td>
<td>T-36, 46</td>
<td>45.6 ± 4.42</td>
<td>46.2 ± 4.77</td>
<td>0.6 ± 0.69</td>
<td>0.024</td>
<td>*</td>
</tr>
<tr>
<td>6.</td>
<td>G-36, 46</td>
<td>33.1 ± 3.07</td>
<td>33.8 ± 2.74</td>
<td>0.6 ± 0.67</td>
<td>0.010</td>
<td>*</td>
</tr>
</tbody>
</table>

*p < 0.05; NS: Nonsignificant
from initial lateral bending of the alveolar process followed by a triangular separation of the maxillary halves with the apex located near the alveolar region. Ciambotti et al.\textsuperscript{14} reported significant buccal tipping of alveolar process by 6° with molar tipping of 6° in the RME group and in the NiTi expansion group found 6.6° buccal tipping of alveolar process with 11.6° of molar tipping. However Cotton\textsuperscript{16} and Hicks\textsuperscript{10} observed asymmetrical angular responses to SME, both dental and skeletal, from right to left in the frontal plane. Oshima\textsuperscript{13} showed histologically that the midpalatal suture opened asymmetrically to the vomer in a monkey treated with RME in 10 days. However, he made no reference to such a response in monkeys subjected to SME. Werz\textsuperscript{14} postulated that an accentuated response on one side of the midpalatal suture was due to variation in rigidity of the skeletal articulation.

### Lateral Cephalogram

#### Linear and Angular Changes

SNA increased by a mean of 1.3° (p < 0.01) and A-SFH by a mean of 1.9 mm (p < 0.05). Whereas SNB and ANB increased by 0.5° and 0.8° respectively (p < 0.05). However, this sagittal change of anterior maxillary contour is not in accordance with the other studies. Tindlund et al.\textsuperscript{2} in 112 CLP patients with the quad-helix appliance reported no change in the sagittal position of anterior maxilla. Hicks,\textsuperscript{10} Werz\textsuperscript{14} also reported no change in the sagittal position of anterior maxilla. But Haas\textsuperscript{3} reported a significant sagittal increase in the retro maxillary region, corresponded to the increased pterygomaxillary gap (opening of the pterygomaxillary fissure) and forward maxillary movement. Whereas Isaacson and Murphy\textsuperscript{12} have reported forward maxillary movement in CLP patients treated with RME, but it was very minimal (less than 0.5 mm) compared to the present study which has been increased by 1.9 mm (p < 0.05).

In the present study mandibular plane angle increased by a mean of 2° (p < 0.001) and resulted in the downward and the backward rotation of the mandible. This clockwise rotation of the mandible during the maxillary expansion is similar to other studies and explained as possibly due to occlusal interference caused by the over expansion.\textsuperscript{2,4,10,11,14} This led to an increase in the SN-OP angle by a mean of 3° (p < 0.001) and a further increase in the total anterior facial height\textsuperscript{20} by a mean of 4.3 mm (p < 0.001). This increased vertical dimension is desirable in most of the CLP patients, as reduced facial height and over closure are elements of the CLP stigma.\textsuperscript{3}

The palatal plane inclination did not show a statistically significant change in the present study. SN-PP angle increased by 1° only. This was confirmed when it was correlated with the linear measurements. The perpendicular distance measured from PNS-FH and ANS-FH increased by a mean of 1.3 and 2 mm respectively (p < 0.05). This accounted for parallel movement of the palatal plane resulting in nonsignificant change of the palatal plane angulation. Werz and Dreskin\textsuperscript{14} reported similar findings. They compared the maxillary anterior movement during expansion to normal growth during the same period and found significant maxillary advancement of 0.5 mm, parallel descent of the palatal plane of 0.4 mm, and clockwise rotation of the mandibular plane of 1.8 degrees as a direct treatment effect.

The present study also showed increase in the inclination of U1 to SN plane by 2° (p < 0.01). This was again confirmed when correlated with the linear variable, i.e. SFH-U1, the distance increased by a mean of 1.6 mm (p < 0.01). However, maxillary molar moved distally by 1.5 mm (p < 0.05) during expansion. This was due to derotation of the molars. Molars that were rotated prior to treatment were derotated simultaneously with the expansion treatment and resulted in the relative distal movement of the molars.

#### Changes Measured on Dental Casts

##### Maxillary Dental Casts

The intercanine width measured at the cusp tips and at the palatogingival margins showed significant changes. T-13, 23 increased by a mean of 4.3 mm (p < 0.01), whereas G-13, 23 increased by 3.38 mm (p < 0.01). The adaptation of the stainless steel arms of the NiTi expander up to the canine region resulted in transfer of expansion forces to the intercanine region and accounted for significant increase in the intercanine width. This quantitative change at the two levels of intercanine width is similar to each other. This means, qualitatively a translatory movement took place in the intercanine region. These observations are further confirmed by a similar pattern of changes in the other regions of the maxillary arch. Bell and Lecompte\textsuperscript{18} found similar increase in the intercanine width of 4.3 mm with the quad-helix appliance. But Frank and Engel\textsuperscript{11} reported 2.74 mm increase in the intercanine width with the same appliance. Whereas Tindlund et al\textsuperscript{2} showed mean increase in the intercanine width of 8.9 mm in unilateral CLP patients, and 11.2 mm increase in the bilateral CLP patients treated with quad-helix appliance. T-14, 24 or T-54, 64 increased by a mean of 5.6 mm, whereas G-14, 24 or G-54, 64 increased by a mean of 4.7 mm (p < 0.001).

Change in the intermolar width is a reflection of the total amount of dental and dentoalveolar expansion produced by the appliances. In the present study intermolar change measured at T-16, 26 increased by a mean of 8.6 mm and at G-16, 26 increased by a mean of 5.4 mm (p < 0.001). Highly significant change in the intermolar region is probably because of the direct placement of NiTi palatal expander to 16, 26.

Bell and Lecompte\textsuperscript{18} showed an increase in the intermolar width of 5.3 mm, whereas Frank and Engel\textsuperscript{11} reported an increase of 5.88 mm with the quad-helix appliance. Ciambotti et al.\textsuperscript{15} in his comparative study of RME vs nitinol expansion, reported an increase in intermolar width of 4.76 mm in the RME group and 6.26 mm in the nitinol expansion group. However, this increase in the intermolar width reported by them are low compared to the present study, as they measured the intermolar width at the cusp tips only.
Mandibular Dental Casts

Postexpansion changes measured on the mandibular dental casts showed insignificant changes except in the intermolar area. T-36, 46 G-36, 46 increased by a mean of 0.6 mm (p < 0.05). This change occurred due to the occlusal forces from the expanded maxillary teeth. But, Sandstrom et al. showed an increase in the mandibular intercanine width by 1.1 mm and intermolar width by 2.8 mm with RME. But, Frank and Engel reported no change in the mandibular intermolar width during maxillary expansion with the quad-helix appliance.

Excellent physical properties like shape memory, transition temperature effect and the super elasticity properties, allowed the nickel-titanium expander to expands the maxilla in to a predetermined size, and in turn reduced patients visits.

However, NiTi palatal expander is not a cost-effective appliance. It is also difficult to place it in low palate cases. Few cleft palate patients with poor socioeconomic status who could not afford the NiTi expander were excluded from the study and quad-helix appliance which was less expensive, was given in these patients to expand the constricted maxilla.

SUMMARY AND CONCLUSION

NiTi expansion in operated cleft patients, showed mainly orthodontic expansion. A highly significant change in the maxillary intermolar region is because of the direct placement of NiTi palatal expander to the maxillary molars.

REFERENCES