Comparative outcome assessment between secondary and tertiary alveolar cleft grafting

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Abstract
Introduction
We performed a retrospective comparison between secondary and tertiary cleft patients.

Materials and methods
Twelve patients with unilateral alveolar clefts were included and divided according to age at the time of alveolar cleft grafting between two groups. Group I included secondary alveolar cleft grafting patients while group II included tertiary alveolar cleft grafting counterparts. All patients received a mandibular symphyseal graft augmented with allogeneic demineralised freeze-dried graft. Review of the clinical and cone beam computed tomography volumetric radiographic assessment at six months and then at one year interval was performed. Statistical analysis of the volumetric data was performed.

Results
The total mean graft volume for group I during follow-up period was 162.60 mm³ while that of group II during follow-up period was 178.79 mm³. However, the mean of resorption throughout the study in the group II exceeded that of the group I. There was no statistical significant difference regarding the mean of graft resorption. Secondary alveolar grafting procedures appear to have enhanced clinical and volumetric results than tertiary grafting on long term in spite of the lack of statistical significant difference.

Conclusion
The clinical and volumetric data discussed support the sound hypothesis of secondary alveolar cleft grafting and promote further efforts in increasing the community awareness regarding this topic.

Introduction
Patients suffering from complete clefts of the lip and palate require continuous interdisciplinary care from birth to adulthood. The osseous closure of the alveolar cleft, which is required for the formation of a stable maxillary dental arch, occupies a special position within the whole concept of cleft lip and palate therapy1. The benefits of alveolar cleft grafting (ACG) include: stabilisation of the maxillary arch, elimination of oronasal fistulae, creation of bony support for subsequent tooth eruption, and reconstruction of the hypoplastic pyriform aperture and soft tissue nasal base support. Moreover, ACG allows placement of dental implants and improvement of the oral hygiene conditions of the patient1,2.

The timing of ACG has been subjected to considerable debate between surgeons. The terminology applied to the different concepts of treatment has been more than confusing3. In 1990, the German Association for Oral and Maxillofacial Surgery adopted a worthy classification of alveolar bone grafting that was based on the stage of dental development while establishing common terminology for surgeons:• Primary bone grafting during the first stage of dentition.
• Secondary bone grafting during the mixed stage of dentition.
• Tertiary bone grafting after completion of the second stage of dentition.

Secondary bone grafting was first presented by Boyne and Sands in 19704. The concept received wide acceptance and was later advocated as the standard of care in many centres. The technique provided all the goals of ACG while affording support for the erupting permanent canines with minimal effect on facial growth.

Various extra and intraoral donor sites have been discussed by surgeons for ACG procedures. The anterior iliac has been widely advocated for the availability of cancellous bone and the ease of harvest. The disadvantages associated with the iliac crest harvest include delayed ambulation and possible gait disturbances1,5. Enemark et al.6,7 published the four year assessment outcome of using mandibular symphyseal grafts (MBG) for ACG compared to anterior iliac crest grafts. They found that bony level of the alveolar graft was satisfactory in both groups but was significantly better in the MBG group of patients.

Enemark’s study agreed with the previous findings that mesenchymal-derived bone (e.g. MBG) used as graft material was supposed to be subjected to less bone resorption compared with endochondral bone (e.g. iliac crest grafts). He explained that this variation in bone formation was attributed to a difference in bony architecture, with a greater fraction of cortical bone in the mesenchymal-derived graft7.

Nique et al.8 performed ACG using allogeneic particulate cancellous
grafts (freeze-dried allografts) in a series of 20 patients with unilateral alveolar cleft defects and concomitant oronasal fistulae. Closure of the associated oronasal fistulae and formation of bone bridge occurred in all cases. Rabie and Chay\(^9\) presented their experience with composite intra-membranous grafts and demineralised bone matrix in 2000. They concluded that this composite graft had superior healing capacity when compare to endochondral bone. Furthermore, they postulated that composite grafts were associated with enhanced volume of regenerated bone.

This study will attempt to present an assessment of a minimally invasive technique for management of the secondary and tertiary alveolar cleft cases.

**Materials and methods**

This work conforms to the values laid down in the Declaration of Helsinki (1964). The protocol of this study has been approved by the relevant ethical committee related to our institution in which it was performed. All subjects gave full informed consent to participate in this study.

Twelve patients were selected retrospectively. Six of these patients were in the age range for secondary ACG and hence were grouped together (group I). The second group included six patients who had received tertiary grafting.

Both groups received a composite autogenous and allogenic graft. The autogenous component was derived from the anterior mandibular symphysis while demineralised freeze-dried bone (*Human allogenic bone, Biotech-Direzion commerciale, Italy*) represented the allogeneic component (Figures 1–7).

These patients were followed up both clinically and radiographically. Clinical assessment was performed on a weekly basis in the first three weeks postoperative then on

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**Figure 1:** Incision design for unilateral cases.

**Figure 2:** Incision design for bilateral case. Minimal reflection of mucoperiosteum is performed over the premaxillary region.

**Figure 3:** Suturing of the nasal mucosa within the alveolar cleft.

**Figure 4:** Genioplasty incision for exposure of the symphyseal region.

**Figure 5:** Harvesting of the symphyseal graft using trephine bur.

**Figure 6:** Harvesting cancellous bone after removal of the cortical window.

**Figure 7:** A. The allogenic bone graft used in the study. B. The composite graft mixed together prior to application into the alveolar cleft.
Research study

Table 1 Data for group I patients

<table>
<thead>
<tr>
<th>Case number</th>
<th>Gender</th>
<th>Age (years)</th>
<th>Type of cleft</th>
<th>Graft volume at six months (/mm³)</th>
<th>Graft volume at 12 months (/mm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Male</td>
<td>11</td>
<td>BCLP</td>
<td>Rt: 327.19 Lt: 86.51</td>
<td>Rt: 300.39 Lt: 82.49</td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>11</td>
<td>UCLP</td>
<td>326.42</td>
<td>319.65</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>11</td>
<td>UCLP</td>
<td>625.44</td>
<td>622.4</td>
</tr>
<tr>
<td>6</td>
<td>Male</td>
<td>11</td>
<td>UCLP</td>
<td>256.53</td>
<td>224.56</td>
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<tr>
<td>10</td>
<td>Female</td>
<td>10</td>
<td>UCLP</td>
<td>267.98</td>
<td>230.21</td>
</tr>
<tr>
<td>11</td>
<td>Female</td>
<td>11</td>
<td>BCLP</td>
<td>Rt: 88.41 Lt: 55.96</td>
<td>Rt: 66.49 Lt: 21.87</td>
</tr>
</tbody>
</table>

Table 2 Data for group II patients

<table>
<thead>
<tr>
<th>Case number</th>
<th>Gender</th>
<th>Age (years)</th>
<th>Type of cleft</th>
<th>Graft volume at six months (/mm³)</th>
<th>Graft volume at 12 months (/mm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Male</td>
<td>13</td>
<td>BCLP</td>
<td>Rt: 206.36 Lt: 59.73</td>
<td>Rt: 195.42 Lt: 46.12</td>
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<tr>
<td>3</td>
<td>Female</td>
<td>16</td>
<td>UCLP</td>
<td>554.20</td>
<td>553.24</td>
</tr>
<tr>
<td>8</td>
<td>Male</td>
<td>13</td>
<td>BCLP</td>
<td>Lt: 114.11 Rt: 111.14</td>
<td>Rt: 107.45 Lt: 100.89</td>
</tr>
<tr>
<td>9</td>
<td>Female</td>
<td>24</td>
<td>UCLP</td>
<td>219.23</td>
<td>160.02</td>
</tr>
<tr>
<td>18</td>
<td>Male</td>
<td>25</td>
<td>UCLP</td>
<td>555.20</td>
<td>305.24</td>
</tr>
<tr>
<td>19</td>
<td>Female</td>
<td>14</td>
<td>UCLP</td>
<td>534.70</td>
<td>467.87</td>
</tr>
</tbody>
</table>

The collected data were revised, coded, tabulated and introduced to a personal computer using Statistical package for Social Science (SPSS 15.0 for windows; SPSS Inc, Chicago, II, 2001). The Independent-Samples t-test was used to assess the statistical significance of the difference between the volumetric measurements of group I compared to those of group II both at the six and 12 months intervals as well as the mean of change in bone volume in both groups. Paired-Samples t-test was used to assess the graft volume at six months compared to that measured at 12 months within each group.

Results

The mean age for group I was 10.8 years, while for group II was 17.5 years, with minimum 13 years and maximum 25 years.

Regarding the clinical assessment, the findings were classified into donor site assessment and recipient site assessment.

Donor site assessment

Donor site healing proceeded normally in both study groups. Two patients reported pain related to the lower incisors that continued two postoperatively. Pulp testing of the involved teeth was performed and the teeth were found to be vital. The patients were followed up and there was resolution of that complaint at the six months interval.

Recipient site assessment

For group I cases, only one case showed graft exposure one week postoperatively. This was managed by graft reduction followed by strict oral hygiene measures. The site healed in two weeks following the graft reduction procedure. The quality of the tissue that covered the graft appeared to be inflamed throughout the follow-up period.

In group II, one case showed recurrence of a labial nasal fistula at a monthly basis. The clinical criteria under assessment included: recurrence of the oronasal fistula, purulent discharge from the recipient site, graft extrusion through the donor site as well as wound dehiscence. Regarding the donor site: sensitivity of the mandibular incisors and the occurrence of chin ptosis or numbness in the distribution of the mental nerve.

Radiographic assessment was performed using cone beam computed tomography (CBCT) at six and 12 month intervals. A panoramic image of the dental arch linked to the axial image and a cross-sectional image perpendicular to the panoramic arch were constructed in the alveolar cleft area.

The interval between the reconstructed images was 1 mm, both in panoramic and cross-sectional images. The grafted area (width—alveolar bone width between adjacent teeth of the cleft, upper edge—lower margin of the anterior nasal aperture and lower edge—alveolar edge adjacent to the cleft) was traced freehand on the axial cross-sectional image while superimposing the shape after bone grafting surgery in the cleft area.

In tracing the bone grafting area, window level and window width were adjusted to clearly extract the border between the bone and cleft at the contacting site between the alveolar cleft and bone on the CBCT image. At sites with an unclear margin, where the alveolar cleft contacted the soft tissue, the grafted area was determined based on the morphology of the unaffected side and left–right symmetry. The volume was calculated based on this data. The Simplant pro ver 8.1 software (Materialize Inc.) was used to superimpose the images of the alveolar cleft region from the preoperative, six months and 12 months postoperative CBCT’s in order to calculate the graft volume at the grafted sites (Figure 8). Measurements were obtained in cubic millimetres.

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The depth of the labial vestibule. This fistula did not discharge any purulent discharge nor did it display fluid or food regurgitation. The recurrence of the fistula occurred one month postoperatively.

The appraisal of ACG was further augmented by volumetric calculations achieved through CBCT images. Mean of graft volume at six months, was higher than that at one year among group I and that difference was statistically significant (Table 3; Figure 1). On the other hand, the mean graft volume at six months was higher than that at one year among group II but that difference was not statistically significant (Table 4; Figure 2).

Total mean graft volume for group I during follow-up period was 162.60 mm³ while the total mean graft volume for group II during follow-up period was 178.79 mm³. Although the mean of graft volume

**Table 3** Comparison between mean graft volumes at different stages among group I during follow-up

<table>
<thead>
<tr>
<th>Group I graft volume (mm³)</th>
<th>N</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>t</th>
<th>p value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>At six months</td>
<td>6</td>
<td>169.54</td>
<td>82.9</td>
<td>3.42</td>
<td>0.02</td>
<td>Significant</td>
</tr>
<tr>
<td>At one year</td>
<td>6</td>
<td>155.67</td>
<td>91.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4** Comparison between mean graft volume at different stages among group II during follow-up

<table>
<thead>
<tr>
<th>Group II graft volume (mm³)</th>
<th>N</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>t</th>
<th>p value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>At six months</td>
<td>6</td>
<td>196.22</td>
<td>85.7</td>
<td>1.86</td>
<td>0.1</td>
<td>Not significant</td>
</tr>
<tr>
<td>At one year</td>
<td>6</td>
<td>161.35</td>
<td>77.7</td>
<td></td>
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</tbody>
</table>
for group II was higher than that for group I either at six months or at one year during follow-up, but that difference was not statistically significant (Table 5; Figure 3).

The mean of change in measurement for group II graft volume was higher than that of group I but the difference was not statistically significant (Table 6; Figure 4).

**Discussion**

Secondary grafting technique was first introduced by Boyne in the 1970s. The technique was immediately received with enthusiasm as it offered a considerable advantage. The technique took into primary consideration the eruption of the permanent teeth whether the maxillary canine or the maxillary incisors. Furthermore, the technique aligned the efforts of both the orthodontic and surgical specialties in one direction which was maintenance of normal growth.

In spite of the relative establishment of the secondary ACG technique, cases of tertiary grafting are still seen in cleft care practice. The presence of patients with clefts who have completely missed ACG procedure until after the eruption of the maxillary canine indicates that the more community awareness is necessary.

The current study provided clinical and radiographic appraisal of two groups of ACG.

In group I (received secondary ACG), the clinical appraisal outlined the occurrence of graft exposure in one case which was managed by local wound care. This finding conforms with similar studies. Prevention of this common complication relies not only on surgical procedure but also patient–parent compliance to oral hygiene instructions. The volumetric assessment of this group revealed a decrease in graft volume between the six months value and the one year counterpart. This can be explained by two biological processes ensuing through the one year period. The first is the process of creeping substitution which takes place in healing of autogenous grafts. The second process is the eruption process of the maxillary canines which includes a phase of bone resorption.

<p>| Table 5 | Comparison between the two studied groups regarding mean graft volume at different stages during follow-up |
|-----------------|-----------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Graft volume (mm³)</th>
<th>N</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>t</th>
<th>p</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>At six months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group I</td>
<td>6</td>
<td>169.54</td>
<td>82.9</td>
<td>-0.55</td>
<td>0.6</td>
<td>Not significant</td>
</tr>
<tr>
<td>Group II</td>
<td>6</td>
<td>196.22</td>
<td>85.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At one year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Group I</td>
<td>6</td>
<td>155.67</td>
<td>91.0</td>
<td>-0.12</td>
<td>0.9</td>
<td>Not significant</td>
</tr>
<tr>
<td>Group II</td>
<td>6</td>
<td>161.35</td>
<td>77.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| Table 6 | Comparison between the two studied groups regarding change in measurement for graft volume |
|-----------------|-----------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Graft volume (mm³)</th>
<th>N</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>t</th>
<th>p</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>6</td>
<td>-13.87</td>
<td>9.9</td>
<td>1.10</td>
<td>0.3</td>
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<tr>
<td>Group II</td>
<td>6</td>
<td>-34.87</td>
<td>45.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 10:** A. Postoperative healing of a unilateral case, B. Postoperative healing of a bilateral case.

**Figure 11:** Comparison between graft volumes in group I during the follow up period.
on the erupting front followed by bone apposition apical to the erupting maxillary canine.

For group II, the clinical appraisal included an event that needs further commentary. There was wound breakdown labial at one point one month following the grafting procedure with absence of nasal regurgitation or purulent discharge. The late occurrence of the fistula is considered relatively odd, however, due to the clinical presentation described no attempts were made to surgically manipulate the graft area further.

Regarding the volumetric assessment of group II, there was again a decrease in graft volume. However, the decrease was more than that seen in group I. This can be explained by the presence of creeping substitution previously discussed without the selective resorption—apposition partner previously mentioned in group I which was related to the erupting successor. However, the lack of any stimulation on the grafted portion of the maxilla resulted in higher resorption rate. The volumetric assessment technique used in this study applied the methodology performed by Ozawa et al.\[11\]. The volumetric figures obtained are comparable to those obtained by Ozwa et al.\[11\] and Alonso et al.\[12\].

The volumetric calculations, as previously stated are not without error. Shiroda et al.\[10\] used CBCT assessment for calculating preoperatively the volume of graft needed to fill the alveolar defect. The preoperative calculated value was then compared to the postoperative value of the actual ACG used, calculated intraoperatively using syringes loaded with the graft. The error between the two was 0.7–0.6 cm³.

**Conclusion**

The clinical and volumetric data discussed support the sound hypothesis of secondary ACG and promote further efforts in increasing the

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**Figure 12**: Comparison between graft volumes in group II during the follow up period.

**Figure 13**: Comparison between the graft volumes in both groups during the follow up period.

**Figure 14**: Comparison between the total change in graft volume between both groups during the follow up period.
community awareness regarding this topic.

Acknowledgement
I would also like to acknowledge the efforts of the staff members of the cleft care clinic of the faculty of dentistry, Ain shams University.

References