Influence of Secondary Bone Grafting on Canine Eruption in Cleft Lip and Palate Patients

Enkhtuvshin GERELTZUL, Yoshiyuki BABA and Kimie OHYAMA

Abstract: Objective: The aim of this study was to investigate the eruption pattern of the cleft side canine concerning its position before eruption to the cleft in secondary bone grafted and non-grafted patients with cleft lip and palate.

Materials and methods: This study includes 22 canines in 21 patients, who had received secondary bone grafting before canine eruption, 17 canines in 16 patients without bone grafting, and 31 canines in non-cleft side as controls. Totally 37 cleft lip and palate patients (70 canines) were examined using panoramic radiographs taken at two stages, before and after canine eruption. According to canine position relative to the cleft site at pre-eruption stage subjects were divided into two groups; I) close to the cleft site, and II) distant from the cleft site. Canine angle, measured between the major axis of the canine and a straight line through both the lowest points of orbital fossa, canine angle change between two stages, and alveolar bone height after its eruption were evaluated.

Results: 1. No significant differences were found between initial canine angles of grafted and non-grafted groups, however control group showed significant high angle compared to grafted (p<0.05) and non-grafted samples (p<0.01). 2. While canines in grafted group erupted without significant angle change, canine angle increased significantly in non-grafted (p<0.01) and control groups (p<0.0001) through eruption. 3. In group I, greater canine angle change was found in non-grafted samples than in grafted samples (p<0.05). However, in group II significant difference was not found between non-grafted and grafted samples. 4. Concerning the alveolar height of canine after eruption, significant difference was not found between grafted and non-grafted samples in both group I and II.

Conclusion: These results suggest that canine located near to the cleft (group I) erupts with the same angulation as it had before grafting in grafted samples, however in non-grafted samples it erupts with more vertical direction, guided by cortical bone. On the other hand, canine distant from the cleft site (group II) erupts with the same angulation change in non-grafted and grafted samples.

Key words: secondary bone grafting, cleft lip and palate, canine eruption, canine inclination
口唇口蓋裂患者における二次骨移植が犬歯の萌出にあたえる影響

Enkhtuvshin Gereltzul 馬場祥行 大山紀美栄

要旨 目的: 本研究の目的は、口唇口蓋裂患者における犬歯の萌出に対して、二次骨移植がいかに関与しているかに関し、萌出前の犬歯と裂隙の位置関係に着目して検討することである。資料ならびに方法: 大歯の萌出前に骨移植術を行った 21 名（22 歯；骨移植群）、骨移植術を行わなかった 16 名（17 歯；非移植群）、および非裂側の大歯（31 歯；対照群）を含む計 37 名の口唇口蓋裂患者の大歯（70 歯）の萌出について検討した。資料として、犬歯の萌出前と萌出後に撮影したオルソパントログラムを用い、裂側の犬歯については、萌出前に裂隙に近接しているもの（group I）と離れているもの（group II）の 2 群に分けた。犬歯の歯軸と左右眼窩下点を通る直線のなす角を大歯角とし、また、萌出後の歯槽骨の高さを評価し、検討した。結果: 1. 骨移植群と非移植群の間には萌出前の犬歯角に有意差を認めなかったが、骨移植群（p＜0.05）および非骨移植群（p＜0.01）と比べ対照群は有意に大きな値を示した。2. 大歯角の萌出前の変化については、移植群では有意差を認めなかったが、非移植群（p＜0.01）および対照群（p＜0.001）においては、萌出後に有意に大きな値を示した。3. 萌出後の大歯角の変化について、骨移植群と非移植群で比較すると、group I においては、骨移植群において有意に小さな値を示したが（p＜0.05）が、group II においては 2 群間に有意差を認めなかった。4. 萌出後の犬歯を支える歯槽骨の高さに関しては、group I と group II のいずれにおいても、骨移植群と非移植群の間に有意の差を認めなかった。結論: これらの結果より、裂隙に近接する犬歯（group I）は、骨移植を行った症例では萌出前の歯軸傾斜を変えるに萌出するが、骨移植を行わないう場合は皮質骨の存在により、より垂直的に萌出する傾向が認められた。一方、裂側から離れている犬歯（group II）においては、骨移植の有無による萌出方向の変化の違いを認めなかった。

キーワード: 二次骨移植、口唇口蓋裂、犬歯の萌出、犬歯傾斜角

Introduction

Since secondary bone grafting became a widely accepted procedure for repair of the alveolar defect in patients with cleft lip and palate, a discussion about the optimal timing for grafting has been raised. The indicator for timing of bone grafting in most studies has involved the age of patient, presence or absence of lateral incisors, crown eruption stage, and root formation stage of the teeth adjacent to the cleft. Since other factors, such as a position of these teeth to the cleft at the timing of grafting, can be one of the indicators for timing, it is preferable to investigate the eruption pattern of these teeth.

The aim of the current study was to investigate the eruption pattern of the cleft side canine concerning its position to the cleft in secondary bone grafted and non-grafted patients on the basis of panoramic radiographs.

Materials

In this study we have involved 37 non-syndromic patients (22 males and 15 females) with unilateral and bilateral cleft lip and palate who were treated at the Orthodontic Clinic, Tokyo Medical and Dental University Hospital. Patients with incomplete cleft lip and alveolus were excluded. The patient cleft type and sex distribution are shown in Table 1. All subjects were divided into three groups; bone grafted (BG), in the patients who underwent secondary bone grafting in hospital since 1987 to 2000 before canine eruption, non-grafted (Non-BG), in the patients treated prior to the introduction of secondary bone grafting to avoid the potential bias of...
Table 1 Distribution of the patients by cleft type and sex

<table>
<thead>
<tr>
<th>Groups</th>
<th>UCLA</th>
<th>UCLP</th>
<th>BCLP</th>
<th>Male</th>
<th>Female</th>
<th>Patients</th>
<th>Canines</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG</td>
<td>3</td>
<td>14</td>
<td>4</td>
<td>14</td>
<td>7</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>NonBG</td>
<td>3</td>
<td>11</td>
<td>2</td>
<td>8</td>
<td>8</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Control</td>
<td>5</td>
<td>26</td>
<td>0</td>
<td>18</td>
<td>13</td>
<td>31</td>
<td>31</td>
</tr>
</tbody>
</table>

UCLA: unilateral cleft lip and alveolus, UCLP: unilateral cleft lip and palate, BCLP: bilateral cleft lip and palate

Table 2 Mean chronological age and tooth developmental stages

<table>
<thead>
<tr>
<th>Groups</th>
<th>Age (mean±SD)</th>
<th>Crown eruption stage</th>
<th>Root developmental stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>BG</td>
<td>10.2±1.2</td>
<td>12.5±0.9</td>
<td>16</td>
</tr>
<tr>
<td>NonBG</td>
<td>9.5±1.3</td>
<td>11.8±1.6</td>
<td>12</td>
</tr>
<tr>
<td>Control</td>
<td>9.7±1.3</td>
<td>12.2±1.6</td>
<td>28</td>
</tr>
</tbody>
</table>

The chronological age, crown eruption stage and foot formation stages of canine were assessed in two stages, pre-eruption (A) and post-eruption (B).
- Crown eruption stage: 1: covered by bone, 2: just penetrating bone, 3: close eruption, 4: erupted
- Root developmental stage: 0: no root, 1: initial root formation, 2: root less than crown, 3: root equal to crown, 4: root longer than crown, 5: root completed (apex open), 6: root completed (apex closed)

Methods

1. The lines and points used in orthopantomograms (Fig. 1)

Reference line (RL), tangent line (TL), canine long axis (CL) and most convex point (O) were defined on the panoramic radiographs. The straight line through the lowest points of both orbital fossa was used as a horizontal reference line. The most convex point was defined as a contact point of alveolar ridge of lesser segment and tangent line, at an angle by 45 degree to reference line.

2. Angular measurements and classification

selection patients to perform the grafting, and non-cleft side canines as control group. The technique of bone grafting was the same as described by Boyne and Sands. Age at the time of secondary bone grafting ranged from 7 years 5 months to 12 years 8 months, with mean age of 10 years 2 months. The measurements were done on panoramic radiographs, taken at two stages, before and after canine eruption, stages A and B respectively, in all three groups. The patients, selected for this research, did not show statistical significant differences in canine crown eruption and root formation stages between three groups (Table 2). The stages of crown eruption and root formation were determined from the panoramic radiographs at before and after eruption stages. The eruption of the crown through the alveolar bone and covering soft tissue was classified into five degrees, and root development (crown/root ratio) was graded on a scale of 0 to 6 according to the method of el Deeb et al (1982).
Fig. 1 Lines and points used in orthopantomograms
RL: reference line, # : bone ridge of lesser segment, TL: tangent line, O: most convex point of bone ridge, CL: canine long axis

Fig. 2 Measurements on orthopantomograms
CA: canine angle, Jm: mesial cemento-enamel junction of canine, Jm': projected point of Jm, which was determined by intersection of tangent line (TL) and a line traced parallel to the canine long axis through Jm point.

Table 3 Distribution of the canines by groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>Group I</th>
<th>Group II</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG</td>
<td>12</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>NOnBG</td>
<td>10</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

To clarify the position of canine to the cleft, two groups were distinguished, according to its position before eruption. The distribution of the canines on each group is shown in Table 3. The intersection of the tangent line and a line which, runs parallel to canine long axis through mesial cemento-enamel junction (Jm) was defined as projected point of mesial cemento-enamel junction (Jm'). When Jm' was to the mesial of most convex point, that canine was considered to be as located closer to the cleft area. That canine was orientated to the cleft with more mesial inclination and was included to group I. If projected point was to the distal of most convex point, the canine was considered to be located distant from the cleft and assumed to erupt into the alveolar ridge, rather than

of canines (Fig. 2)

Following the method described by Bjerklin and Kurol for the first maxillary molars and modified for the upper canine by Fernandez et al., we measured the internal angle formed by the long axis of the canine and the reference line.
cleft area and was included to group II.

3. Interalveolar septal height
The interalveolar septal height was evaluated after canine eruption\(^1\). The interalveolar septal height, which was approximately normal or at least three forth of normal height was assessed as clinically acceptable, others where septum height was less than three-fourth of normal height as poor.

4. Statistical analysis
ANOVA (Fisher's PLSD) was used to compare age of the patients, initial angles and angle changes among three groups. Paired t-test was used to evaluate the change of angles until a full eruption of canine in every group. Chi-square test was used to evaluate crown eruption and root formation stages of canine among three groups and interalveolar septal height between bone grafted and non-grafted groups. Mann-Whitney test was performed to compare angle change between grafted and non-grafted samples on each group I and II. The data were examined for statistical significance at a probability level of 0.05. The statistical analysis was performed using Stat View 5.0 software on a personal computer system.

To assess the reliability of the measurements ten orthopantomograms, taken at random, were re-traced on a separate occasion. The standard errors of the method were assessed by the use of Dahlberg's formulae.\(^{10}\) For angular measurement the error of the method was 0.78.

Results

1. Canine angle
The canine angle was measured in two stages, before eruption and after eruption. Fig. 3 shows the initial canine angles in three groups. No significant differences were noted between initial angles of bone grafted (76.7 ± 8.0) and non-grafted groups (74.6 ± 10.8), however control group showed significant high angle (82.8 ± 9.5) compared to grafted (p<0.05) and non-grafted samples (p<0.01). The result of canine angle change through its eruption is shown in Fig. 4. Canine in grafted group erupted without significant angle changes (76.7 ± 8.0 to 78.5 ± 13.8). While canines of non-grafted (74.6 ± 10.8 to 83.9 ± 8.7) and control groups (82.8 ± 9.5 to 90.9 ± 6.2) erupted with significant angle changes (p<0.01 and p<0.0001, respectively).

Concerning a comparison of canine angle changes among three groups, greater angle change was found in non-grafted samples (p<0.05) and control (p<0.05) than those of grafted ones, however no significance was found between non-grafted and control groups (Fig. 5).

2. Canine angle changes according its position
In order to clarify the influence of initial canine position to the eruption pattern, all
Fig. 4 Canine angle change through its eruption in three groups
A: before canine eruption, B: after canine eruption
**: p<0.01, ***: p<0.001, NS: not significant

Fig. 5 Comparison of mean canine angle changes by groups
*: p<0.05, NS: not significant

canines of cleft side were divided to two groups as described before; group I, where canine was located closer to cleft region, and group II where canine was located distant from the cleft. Significant difference of mean angle change was found between grafted and non-grafted cases of group I (p<0.05). However no significant difference was found in group II (Fig. 6).

3. Interalveolar septal height
Concerning the alveolar height of canine after its eruption, no significant difference was found between grafted and non-grafted patients in both group I and group II (Table 4).

Discussion
Secondary bone grafting would mainly affect the eruption path of canine mesio-distally. So this study was conducted to investigate the eruption pattern of canine in terms of its inclination by using orthopantomograms. A panoramic view has provided a
very useful survey of the erupted and unerupted dentition, related dento-alveolar supporting structures. Fernandez et al.\textsuperscript{14} have analyzed the eruption pattern of canine eruption on the basis of panoramic radiographic records. Even the orthopantomographic films would be suitable to distinguish the relation of the cleft and the adjacent canine in terms of its inclination, the eruption pattern of upper canine would be investigated three dimensionally in further study using other radiographic methods such as computed tomography (CT).

There have been some works where the reliability of measurements on panoramic radiographs was investigated\textsuperscript{25-31}. These studies showed that angular measurements could be performed on panoramic radiographs.

According to the studies on the eruption pattern of canine in non-cleft children\textsuperscript{24,32,33}, Fernandez et al.\textsuperscript{14} have found that “canine erupts, increasing its inclination mesially until a maximum is reached, after which the tooth begins to progressively upright itself”. In our study the canine eruption pattern in cleft lip and palate patients was studied and compared between grafted, non-grafted and control groups, by measuring its angle before and after eruption on orthopantomograms\textsuperscript{30}.

The teeth, which did not show significant differences in root formation stage, were chosen to avoid the influence of different positions and angles of dental follicle in its different developmental stages. The results showed that the initial angle of upper canine in bone grafted and non-grafted groups was significant different from control group. The existence of the cleft itself might play a role for different angles, however the exact reason is still uncertain.

During normal eruption the canine displaces toward the occlusal plane, straightening gradually and deviating toward a more vertical position. Broadbent\textsuperscript{30} established that “the upper cuspids move downward, forward and laterally away from the root ends of the laterals”. Fernandez et al.\textsuperscript{14}, have found that “lateral movement and gradual straightening of the canine would take a place in a second eruptive stage”. In our study the same eruption pattern was observed in control and non-grafted groups. This eruption pattern in non-grafted group may occur because of eruption of the teeth by guidance of cortical bone. Although canine readily erupts through a graft after bone grafting\textsuperscript{32,33}, its eruption pattern is unclear yet\textsuperscript{33}. In our study, canine in grafted group erupted without significant angle change. The presence of newly grafted bone may influence on this eruption pattern of canines.

Lilja et al.\textsuperscript{31} have found that in 22% of patients whose canine crown was covered by only thin shell of bone and was just before eruption, the root formation stage was less than 1/4. So they suggested to consider the thickness of bone covering the crown rather than root developmental stage to determine the timing of the bone grafting. On the basis of these findings, to investigate the possibility of using canine position to the cleft as one indicator for the adequate timing for secondary bone grafting, in our study all canines were divided to two groups according to its position before eruption regarding to

<table>
<thead>
<tr>
<th>Groups</th>
<th>Acceptable</th>
<th>Poor</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BG</td>
<td>10</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>NonBG</td>
<td>7</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Group II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BG</td>
<td>10</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>NonBG</td>
<td>7</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

NS: not significant
the cleft. Canine located closer to the cleft or covered by thinner bone and orientated to the cleft with more mesial canine inclination was included to group I, while canine located distant from the cleft and assumed to erupt to the alveolar ridge, rather than cleft was included to group II.

The canine of group I in non-grafted samples erupted with greater angle change than that of bone grafted samples. These results showed that while in grafted samples canine erupted with the same angle as it had before grafting, in non-grafted samples canine erupted with more vertical position, probably guided by cortical bone. On the other hand, in group II canine erupted without differences between grafted and non-grafted samples. The distant location of canine from the cleft might have less influence on eruption path. In this study 85.7% of canines in group I and 50% in group II erupted through newly grafted bone with spontaneous space closure. Rest of these cases required orthodontic or prosthodontic space closure.

The aim and benefit of secondary bone grafting have been defined previously by many authors\textsuperscript{1,2,9,20-22}, the teeth adjacent to the cleft with good bone support and without alveolar notching seem to be the most commonly cited criteria. Bergland et al.\textsuperscript{1} established a semi quantitative evaluation of the height of the interalveolar septum. Canines having erupted through the grafted region showed periodontal conditions similar to those of the contralateral canine\textsuperscript{22}. In our study the interdental alveolar height was measured after canine eruption in both grafted and non-grafted samples. The interalveolar septal height did not show significant difference between grafted and non-grafted samples in group I, possibly as a result of greater angle changes of canine during its eruption. However, poor bone support was found only in non-grafted samples of group I.

Conclusions

The influence of secondary bone grafting on canine eruption was investigated in this study. Canine, located near to the cleft (group I), erupts with the same angulation as it had before grafting in grafted group, however in non-grafted samples it erupts with more vertical direction, same as canine in non-cleft side of control group. On the other hand, canine distant from the cleft (group II) erupts with the same angulation changes in non-grafted and grafted samples.

References

7) Long, R.E., Paterno, M., Vinson, B.: Effect of cuspid positioning in the cleft at the time of secondary alveolar bone grafting on eventual graft success. Cleft Palate J.,


