EVALUATION OF PROXIMAL ALVEOLAR BONE LEVEL CHANGES DURING ORTHODONTIC TREATMENT - A COMPARATIVE CLINICAL STUDY

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Abstract:
The aim of this clinical study was to evaluate the iatrogenic effect of orthodontic treatment on interproximal crestal alveolar bone and to compare the changes in cases treated by Preadjusted Edgewise Appliance and those treated by the Begg Appliance. Two study groups comprising of 10 patients each were treated with either of the appliances. The radiographic method - Absolute technique as described by Albander et al- was used for quantification of crestal alveolar bone. Two radiographic examinations were performed, one at the start of treatment and second at the end of the orthodontic treatment. Each included two intra-oral periapical (IOPA) radiographs of the maxillary anterior region (right canine to left canine) taken using the paralleling technique. Measurements were made on the IOPA films and the results evaluated.

Keywords:
Alveolar bone crest, iatrogenic damage, comparison Begg and PEA

Introduction
One of the oft-stated objectives of orthodontic treatment is to promote better dental health and prolong the life of the dentition. In practice, however, there are definite risks in undertaking orthodontic treatment with fixed appliances such as root resorption, caries and decalcification, enamel surface marring or enamel fractures, soft tissue damage, gingival inflammation, gingival hyperplasia, reduction in the height of alveolar crest or elimination of the alveolar bone wall. Some authors have reported a considerable amount of pathological destruction of crestal bone; others have observed very minimal changes, while some authors have found no effect of orthodontic forces on the proximal alveolar bone.

This study was undertaken with the following objectives:
1) To radiographically evaluate the amount of change in the height of interproximal alveolar bone level caused by orthodontic tooth movement.
2) To compare the changes in cases treated by Preadjusted Edgewise Appliance and those treated by the Begg Appliance.

MATERIALS AND METHODS
The study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, A.B. Shetty Memorial Institute of Dental Sciences, Derlakatte, Mangalore, Karnataka.

CRITERIA FOR PATIENT SELECTION
1) All patients had a Class I skeletal base.
2) All patients required the extraction of maxillary first premolars for correction of crowding, overbite and proclination of teeth.
3) All maxillary teeth were present in all patients with no history or evidence of trauma.
4) The presence of traumatic bite was ruled out in all patients.
5) The age and sex of the patients were not considered.
6) All patients had received oral prophylaxis in the Department of Periodontics of the same institution, which included supra-gingival and sub-gingival scaling as well as education about the oral hygiene techniques and the importance of maintaining good oral hygiene especially with the orthodontic appliance.

GROUP A
This consisted of 10 patients who were treated using the Begg Appliance (Table I). They had completed the first two stages of treatment using the appliance which lasted for 10-12 months.

Stage I comprised of the following:
a) Decrowding using 0.016” diameter preformed Nitinol wire
b) Bite opening, reduction of overjet and achieving an edge to edge bite using 0.016” diameter A.J. Wilcock Special Plus archwire with approximately 30° anchor bends in combination with Class II elastics delivering forces of approximately 2 ounces.

Stage II comprised of the following:
a) Closure of remaining extraction spaces using 0.018” diameter A.J. Wilcock Special Plus archwire along with Class I elastics delivering forces of approximately 3 ounces.

b) Maintenance of an edge to edge bite with approximately 20° anchor bends in the archwire and Class II elastics delivering forces of approximately 2 ounces.

GROUP B
This consisted of 10 patients who were treated using the Preadjusted Edgewise Appliance (Table I) of the Roth Prescription having 0.022” × 0.028” slot. The treatment which lasted for a period of 10-12 months comprised of the following:
a) Decrowing using 0.016” diameter preformed Nitinol wire.
b) Leveling of Curve of Spee using 0.016” diameter reverse curve Nitinol wire.
c) Closure of extraction spaces using the sliding mechanism with 0.017” × 0.025” stainless steel archwire in combination with elastic modules and stainless steel ligature wires (diameter 0.010”)

Routine home care instructions were given to all patients. The oral hygiene was analysed every second appointment (every 6 weeks) with the aid of a disclosing solution (Plaksee with erythrosine) and the Turesky-Gilmore-Glickman modification of the Quigley-Hein Plaque Index. A high Index score indicated that the patient was not adequately maintaining his/her oral hygiene. Such patients and their parents were given special instructions and were educated about the importance of maintaining good oral hygiene.

RADIOGRAPHIC EXAMINATION
Two radiographic examinations were performed, one at the start of treatment and second at the end of the above mentioned treatment. Each included two intraoral periapical (IOPA) radiographs of the maxillary anterior region (right canine to left canine) taken using the paralleling technique. XCP (extension cone paralleling) instruments were used for positioning the X-Ray film in the patient’s mouth. Radiographs were taken using a dental x-ray unit (Explor-X) using a long cone. Dental X-ray film (Kodak) was used and developed as recommended by the manufacturer.

The radiographs were analysed under a magnifier of x10 magnification for precise location of the landmarks. The landmarks were marked with a fine marker on the radiographs. Measurements were made to the nearest 0.1 mm using calipers, directly on the radiographs.

To measure the proximal alveolar bone level, interproximal measurements were made of the distance between the cemento enamel junction (CEJ) and the
alveolar bone crest (AC), along a line parallel to the long axis of the tooth using the Absolute technique as described by Albander et al.\(^{18}\) (1985). The CEJ was defined as the connection between the root surface and the crown enamel, and the AC as the most coronal level where the periodontal membrane retained its normal width.\(^{7,8,9}\)

A widening of the cervical part of the periodontal membrane was considered to be bone loss only if accompanied by evidence of oblique resorption. A site was scored as unreadable if at least one of the reference points could not be identified.

The proximal distance between CEJ and AC was measured at 10 sites of each subject, viz. the mesial surfaces of the right and left maxillary canines, the mesial and distal surfaces of the two lateral incisors and the mesial and distal surfaces of the two central incisors. Hence, altogether 200 sites were measured.

To eliminate magnification errors, the following formula was used which was based on the one given by Linge and Linge \(^{19}\)(1991). This formula scaled down both the radiographs to the same magnification, that of the first IOPA film.

\[
\text{Proximal bone loss} = d_2 (c_1 \div c_2) - d_1
\]

where \(d_1\) represents CEJ-AC distance before treatment
\(d_2\) represents CEJ-AC distance after treatment
\(c_1\) represents crown length before treatment
\(c_2\) represents crown length after treatment

The crown of the central incisor was measured in each radiograph. To calculate bone loss values of the right sided teeth, \(c_1\) and \(c_2\) of the right central incisor were taken and to calculate bone loss values of left sided teeth, \(c_1\) and \(c_2\) of the left central incisor were substituted in the formula. If the crown of the central incisor was incomplete in the radiograph, lateral incisor was used for the same purpose.

The crown length was measured as the distance between the line joining the mesial and distal incisal angles and the line joining the mesial and distal CEJ.\(^{19}\) This method was based on the assumption that the true dimension of the crown remained constant during the course of treatment.

All IOPA radiographs have been associated with a general magnification of the factor 1.03 according to Baumrind, Korn and Boyd\(^{19}\) (1996). Thus, the bone loss values were then divided by 1.03 to obtain absolute values.

\[
\text{Actual Proximal bone loss} = \left[ d_2 \left( c_1 \div c_2 \right) - d_1 \right] \div 1.03
\]

The values of proximal bone loss of Group A and Group B were compared and analysed. Statistical analysis of difference between paired data was performed using Student's t-test. Differences with probabilities of less than 5% (p<0.05) were considered to be statistically significant.

**RESULTS**

Altogether, 200 sites were analysed. 12 sites were excluded because the CEJ or AC could not be identified. The CEJ-AC distances were measured for the remaining 188 sites.

**Tables II to VI** show the values measured and the comparisons of the two observation groups.

**DISCUSSION**

This study was primarily concerned with the ultimate condition of the interproximal alveolar bone after major orthodontic treatment using the Begg Appliance and the Preadjusted Edgewise Appliance. The radiographic method was used for quantification of crestal alveolar bone as it is a well accepted technique and has been proved superior to other clinical methods as it can be easily standardized.\(^{1,5,7,21}\)

The results showed an increase in CEJ-AC distances signifying loss of interproximal alveolar bone in both the study groups (**Tables II and III**). The values were statistically very highly significant (p<0.001) for all sites in both the groups. This showed that loss of interproximal alveolar bone does occur regardless of the technique used. The cause was attributed to the use of orthodontic forces since all other causes of bone loss including plaque were eliminated. The result was in accordance with those of earlier investigations which indicated loss of interproximal alveolar bone during orthodontic treatment.\(^{2,3,5,6,7}\)

In **Group A** (Begg Appliance) the mean bone loss values obtained for each site ranged from 0.13 ± 0.05 mm to 0.22 ± 0.07 mm. The minimum value of bone loss recorded was 0.050 mm while the maximum value recorded was 0.347 mm (**Table II**). In **Group B** (Preadjusted Edgewise Appliance), the mean bone loss values obtained for each site ranged from 0.07 ± 0.02 to 0.15 ± 0.08. The minimum value of bone loss recorded was 0.019 mm while the maximum value recorded was 0.291 mm (**Table III**).

This relatively large variability of the results in both groups matched with those obtained by Hollender, Ronnerman and Thilander\(^{4}(1980)\), who reported large intra individual as well as inter individual variations in
loss of crestal alveolar bone. The reason for this variability could be attributed to the variables not considered in the study influencing the precise force delivery system such as

a) anatomical variables as dimensions of the tooth and the alveolar bone, the crown to root ratios, width of the periodontal ligament space and mechanical properties of the periodontium.

b) point of force application in relation to the center of resistance.

c) ultimately the moment-to-force ratio which is very difficult to standardise.

In Group A, the mean bone loss for the mesial sites was 0.155 ± 0.027 mm which was less than the mean bone loss value for the distal sites which was 0.197 ± 0.026 mm. The difference was statistically significant. Similar trends were observed in Group B where the mean bone loss value for the mesial sites was 0.093 ± 0.015 mm as compared to 0.125 ± 0.019 mm for the distal sites. The difference was statistically highly significant. (Table V).

These results matched with those obtained by Sjolien and Zachrisson* (1973) who reported a greater bone support on the mesial side than the distal side of the teeth. The cause of the difference was attributed to the distal movement of the teeth during orthodontic movement.

CEJ-AC distance exceeding 2 mm shows significant loss of bone support 22, 23. In Group A and Group B, there were no such sites indicating that the teeth maintained adequate bone support after orthodontic therapy.

In Group A, the mean bone loss value was 0.172 ± 0.033 mm as compared to 0.106 ± 0.022 mm of Group B (Table VI). These values corresponded with those obtained by Ogaard* (1988) who reported who reported a mean crestal bone loss of 0.10 mm in the upper incisor region.

Group A had a higher mean value of bone loss as compared to Group B and the difference of the values was statistically very highly significant (p>0.001). This indicated that Preadjusted Edgewise Appliance causes a more “physiological” tooth movement leading to reduced loss of crestal alveolar bone as compared to that caused by the Begg Appliance.

The results obtained for Group A also indicate that further crestal bone loss is expected during Stage III of the treatment when root tipping and torquing will take place.

The only comparative study done earlier that comes close to our study was the one done by Baxter12 (1967) when he compared proximal alveolar bone levels in cases treated by the Edgewise and the Begg appliances. However, he evaluated the posterior segments and found statistically non-significant results. Thus, our study differs from the results of this study.

CONCLUSION
The results indicated the following:

a) Loss of proximal alveolar bone did occur during orthodontic treatment but the teeth maintained adequate bone support after orthodontic therapy.

b) There was a relatively large variability of bone loss results obtained in both the study groups.

c) There was significantly more loss of proximal bone on the distal sides of the tooth as compared to the mesial sides.

d) The Begg appliance caused a significantly higher loss of proximal alveolar bone as compared to the Preadjusted Edgewise Appliance.

It was concluded from the study that Preadjusted Edgewise Appliance caused a more “physiological” tooth movement as compared to the Begg appliance even though significant bone loss did occur in both using the current force levels. The use of lighter forces and further modifications in mechanics may be able to reduce further this iatrogenic damage to crestal alveolar bone.

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### TABLE I

**MEAN VALUES OF GROUP A AND GROUP B AT THE OBSERVATION PERIOD**

<table>
<thead>
<tr>
<th></th>
<th>Group A (Mean)</th>
<th>Group B (Mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age</td>
<td>16.7 years</td>
<td>17.1 years</td>
</tr>
<tr>
<td>2. Sex (F:M)</td>
<td>7:3</td>
<td>8:2</td>
</tr>
<tr>
<td>3. Proclination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - NA (Linear)</td>
<td>12.1 mm</td>
<td>11.7 mm</td>
</tr>
<tr>
<td>1 - NA (Angular)</td>
<td>33.6°</td>
<td>31.7°</td>
</tr>
<tr>
<td>4. Overjet</td>
<td>5.2 mm</td>
<td>4.8 mm</td>
</tr>
<tr>
<td>5. Arch Discrepancy</td>
<td>1.1 mm</td>
<td>0.7 mm</td>
</tr>
<tr>
<td>6. Overbite</td>
<td>31.0%</td>
<td>33.5%</td>
</tr>
</tbody>
</table>

# Proclination and arch discrepancy values are of the maxillary anterior segment.
# F:M ratio denotes Female: Male ratio

### TABLE II

**CHANGES IN DISTANCE (mm) BETWEEN THE CEMENTOENAMEL JUNCTION (CEJ) AND THE ALVEOLAR BONE CRECT (AC) IN GROUP A**

<table>
<thead>
<tr>
<th>Tooth surface</th>
<th>No of sites</th>
<th>Mean ± SD</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Test of Significance(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right canine mesial</td>
<td>9</td>
<td>0.13 ± 0.05</td>
<td>0.059</td>
<td>0.194</td>
<td>7.80 ****</td>
</tr>
<tr>
<td>Right lateral incisor distal</td>
<td>10</td>
<td>0.17 ± 0.08</td>
<td>0.042</td>
<td>0.345</td>
<td>6.72 ****</td>
</tr>
<tr>
<td>Right lateral incisor mesial</td>
<td>10</td>
<td>0.13 ± 0.09</td>
<td>0.050</td>
<td>0.347</td>
<td>4.57 ****</td>
</tr>
<tr>
<td>Right central incisor distal</td>
<td>10</td>
<td>0.22 ± 0.07</td>
<td>0.097</td>
<td>0.291</td>
<td>9.94 ****</td>
</tr>
<tr>
<td>Right central incisor mesial</td>
<td>10</td>
<td>0.20 ± 0.09</td>
<td>0.062</td>
<td>0.291</td>
<td>7.03 ****</td>
</tr>
<tr>
<td>Left central incisor mesial</td>
<td>9</td>
<td>0.17 ± 0.05</td>
<td>0.097</td>
<td>0.260</td>
<td>10.20 ****</td>
</tr>
<tr>
<td>Left central incisor distal</td>
<td>10</td>
<td>0.22 ± 0.06</td>
<td>0.155</td>
<td>0.291</td>
<td>11.60 ****</td>
</tr>
<tr>
<td>Left lateral incisor mesial</td>
<td>10</td>
<td>0.15 ± 0.05</td>
<td>0.072</td>
<td>0.194</td>
<td>9.49 ****</td>
</tr>
<tr>
<td>Left lateral incisor distal</td>
<td>9</td>
<td>0.18 ± 0.07</td>
<td>0.070</td>
<td>0.291</td>
<td>7.71 ****</td>
</tr>
<tr>
<td>Left canine mesial</td>
<td>8</td>
<td>0.15 ± 0.07</td>
<td>0.079</td>
<td>0.267</td>
<td>6.06 ****</td>
</tr>
</tbody>
</table>

**** Very Highly Significant p < 0.001
### TABLE III

**CHANGES IN DISTANCE (mm) BETWEEN THE CEMENTOENAMEL JUNCTION (CEJ) AND THE ALVEOLAR BONE CRECT (AC) IN GROUP B**

<table>
<thead>
<tr>
<th>Tooth surface</th>
<th>No of sites</th>
<th>Mean ± SD</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Test of Significance(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right canine mesial</td>
<td>8</td>
<td>0.09 ± 0.04</td>
<td>0.047</td>
<td>0.170</td>
<td>7.12</td>
</tr>
<tr>
<td>Right lateral incisor distal</td>
<td>10</td>
<td>0.15 ± 0.08</td>
<td>0.019</td>
<td>0.256</td>
<td>5.93</td>
</tr>
<tr>
<td>Right lateral incisor mesial</td>
<td>9</td>
<td>0.07 ± 0.02</td>
<td>0.043</td>
<td>0.097</td>
<td>11.07</td>
</tr>
<tr>
<td>Right central incisor distal</td>
<td>10</td>
<td>0.13 ± 0.07</td>
<td>0.047</td>
<td>0.266</td>
<td>5.89</td>
</tr>
<tr>
<td>Right central incisor mesial</td>
<td>9</td>
<td>0.11 ± 0.07</td>
<td>0.056</td>
<td>0.252</td>
<td>4.97</td>
</tr>
<tr>
<td>Left central incisor mesial</td>
<td>9</td>
<td>0.10 ± 0.07</td>
<td>0.065</td>
<td>0.291</td>
<td>4.29</td>
</tr>
<tr>
<td>Left central incisor distal</td>
<td>10</td>
<td>0.11 ± 0.04</td>
<td>0.074</td>
<td>0.175</td>
<td>8.70</td>
</tr>
<tr>
<td>Left lateral incisor mesial</td>
<td>10</td>
<td>0.10 ± 0.04</td>
<td>0.064</td>
<td>0.194</td>
<td>7.91</td>
</tr>
<tr>
<td>Left lateral incisor distal</td>
<td>10</td>
<td>0.11 ± 0.03</td>
<td>0.070</td>
<td>0.162</td>
<td>11.00</td>
</tr>
<tr>
<td>Left canine mesial</td>
<td>8</td>
<td>0.09 ± 0.02</td>
<td>0.070</td>
<td>0.097</td>
<td>13.25</td>
</tr>
</tbody>
</table>

**** Very Highly Significant \( p < 0.001 \)
### TABLE IV

**COMPARISON OF CHANGES IN DISTANCE (mm) BETWEEN THE CEMENTOENAMEL JUNCTION (CEJ) AND THE ALVEOLAR BONE CREST (AC) IN GROUP A AND GROUP B**

<table>
<thead>
<tr>
<th>Tooth surface</th>
<th>Group A Mean ± SD</th>
<th>Group A Mean ± SD</th>
<th>Test of Significance(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right canine mesial</td>
<td>0.13 ± 0.05</td>
<td>0.09 ± 0.04</td>
<td>1.98</td>
</tr>
<tr>
<td>Right lateral incisor distal</td>
<td>0.17 ± 0.08</td>
<td>0.15 ± 0.08</td>
<td>0.56</td>
</tr>
<tr>
<td>Right lateral incisor mesial</td>
<td>0.13 ± 0.09</td>
<td>0.07 ± 0.02</td>
<td>2.06</td>
</tr>
<tr>
<td>Right central incisor distal</td>
<td>0.22 ± 0.07</td>
<td>0.13 ± 0.07</td>
<td>3.13</td>
</tr>
<tr>
<td>Right central incisor mesial</td>
<td>0.20 ± 0.09</td>
<td>0.11 ± 0.07</td>
<td>3.46</td>
</tr>
<tr>
<td>Left central incisor mesial</td>
<td>0.17 ± 0.05</td>
<td>0.10 ± 0.07</td>
<td>2.57</td>
</tr>
<tr>
<td>Left central incisor distal</td>
<td>0.22 ± 0.06</td>
<td>0.11 ± 0.04</td>
<td>4.46</td>
</tr>
<tr>
<td>Left lateral incisor mesial</td>
<td>0.15 ± 0.05</td>
<td>0.10 ± 0.04</td>
<td>2.47</td>
</tr>
<tr>
<td>Left lateral incisor distal</td>
<td>0.18 ± 0.07</td>
<td>0.11 ± 0.03</td>
<td>2.76</td>
</tr>
<tr>
<td>Left canine mesial</td>
<td>0.15 ± 0.07</td>
<td>0.09 ± 0.02</td>
<td>2.61</td>
</tr>
</tbody>
</table>

* Not Significant \( p > 0.05 \)
** Significant \( p < 0.05 \)
*** Highly Significant \( p < 0.01 \)
**** Very Highly Significant \( p < 0.001 \)
### TABLE V
COMPARISON OF MEAN PROXIMAL BONE LOSS VALUES OF MESIAL AND DISTAL TOOTH SURFACES IN GROUP A AND GROUP B

<table>
<thead>
<tr>
<th>Tooth surface</th>
<th>Mean ± SD</th>
<th>Test of Significance(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mesial</td>
<td>0.155 ± 0.027</td>
<td>2.51</td>
</tr>
<tr>
<td>Distal</td>
<td>0.197 ± 0.026</td>
<td>**</td>
</tr>
<tr>
<td><strong>Group B</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mesial</td>
<td>0.093 ± 0.015</td>
<td>2.97</td>
</tr>
<tr>
<td>Distal</td>
<td>0.125 ± 0.019</td>
<td>***</td>
</tr>
</tbody>
</table>

### TABLE VI
COMPARISON OF MEAN PROXIMAL BONE LOSS VALUES (GROUP MEAN VALUES) OF GROUP A AND GROUP B

<table>
<thead>
<tr>
<th></th>
<th>Mean ± SD</th>
<th>Test of Significance(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group A</strong></td>
<td>0.172 ± 0.033</td>
<td>5.26</td>
</tr>
<tr>
<td><strong>Group B</strong></td>
<td>0.162 ± 0.022</td>
<td>****</td>
</tr>
</tbody>
</table>

* Not Significant \( p > 0.05 \)
** Significant \( p < 0.05 \)
*** Highly Significant \( p < 0.01 \)
**** Very Highly Significant \( p < 0.001 \)
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7. Illustrations: All figures (Fig.) must be mentioned sequentially in the text. Each figure must be accompanied by a legend, typed on a separate paper. The illustrations must be of good quality. Good black and white photographs are preferred for black and white reproduction. Coloured photographs will be published at author’s expense where a coloured glossy print is preferred. Cost of coloured printing would be Rs. 500/- ($ 20) per postcard size photograph in addition to Rs. 600/- ($ 25) towards additional printing charges. Photographs of x-rays should be sent and not the original x-rays.

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Prints should be clear and glossy. On the back of each print in the upper right corner, write lightly the figure number and author’s name, indicate top of the photograph with an arrow or word ‘ToP’.

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