Buccolingual inclinations of posterior teeth in subjects with different facial patterns

Guilherme Janson, DDS, MSc, PhD, MRCDC, Roberto Bombonatti, DDS, MSc,
Karina Santana Cruz, DDS, MSc, Cristina Yuka Hassunuma, DDS, and
Marinho Del Santo Jr, DDS, MS, MSD, PhD

Bauru, São Paulo, Brazil

This study compared the buccolingual inclination of the posterior teeth in subjects with a horizontal growth pattern (proportionally short lower anterior face height) with that of subjects with a vertical growth pattern (proportionally long lower anterior face height). Seventy subjects with permanent dentition were divided into 2 groups. Group I comprised 35 subjects (16 male, 19 female) with Class II Division 2 malocclusion with a horizontal growth pattern, and group II comprised 35 subjects (15 male, 20 female) with a vertical growth pattern. Buccolingual inclinations of the first molar and second premolar were indirectly assessed on photocopies of buccolingual sections of these teeth by measuring their occlusal surface (represented by an imaginary line connecting the lingual and buccal cusps) inclination. The groups were compared with t tests (P < .05). The maxillary posterior teeth of subjects with a vertical growth pattern had a significantly greater buccal inclination compared with those of subjects with a horizontal growth pattern. However, there were no statistically significant differences in the inclinations of the mandibular posterior teeth between the 2 groups. (Am J Orthod Dentofacial Orthop 2004;125:316-22)

Factors such as age, sex, and ethnic group are important in making a proper orthodontic treatment plan; another important factor is the facial growth pattern and its several clinical characteristics. Facial growth pattern is established at an early age, before eruption of the maxillary first molars. Facial skeletal characteristics of subjects with a vertical growth pattern include increased total face height, especially the lower anterior face height, high mandibular plane angle, clockwise mandibular rotation, short mandibular ramus, and high gonial angle. Opposite aspects are present in subjects with a horizontal growth pattern. Regarding the dentoalveolar aspects, the maxillary dental arches of subjects with a vertical pattern are narrower, with a tendency toward posterior crossbite and anterior open bite. Broader dental arches and accentuated overbite are observed in subjects with a horizontal growth pattern.

It has been suggested that subjects with long lower face height have posterior teeth with greater buccal inclinations and longer functional lingual cusps, and, conversely, that subjects with short lower anterior face height have a greater lingual inclination of the posterior teeth and longer buccal cusps. However, Ross et al found no statistical differences in molar inclination between these facial types. Others have confirmed part of the hypothesis and found that the posterior teeth in people with a short facial type were more linguually inclined than in those with a long facial type, in vertical sections of the mandibular body. The present study was undertaken to further investigate this characteristic of subjects with different facial patterns. The existence of significant differences between these extreme facial patterns might have implications for distinct therapeutic approaches.

We compared the buccolingual inclinations of the posterior teeth in subjects with a definite horizontal growth pattern (proportionally short lower anterior face height) with those in subjects with a definite vertical growth pattern (proportionally long lower anterior face height).

MATERIAL AND METHODS

The final sample included the pretreatment dental study models of 70 subjects, divided into 2 groups: horizontal and vertical facial growth patterns. The models were selected from an initial sample of 120 subjects with permanent dentition who voluntarily
sought orthodontic treatment at the Department of Orthodontics at Bauru Dental School, University of São Paulo, Brazil. The initial sample consisted of 60 subjects (group I) with Class II Division 2 malocclusions and short lower anterior face height, and 60 subjects (group II): with Class II Division 1 malocclusions and Class I malocclusions, with or without open bite and long lower anterior face height; all subjects were evaluated only by visual inspection of frontal and profile facial color photographs. From each subject of this broader sample, a lateral cephalometric radiograph was used. The cephalograms were traced on acetate by a single investigator (R.B.), and the ratio between upper and lower anterior face height was determined. The 70 subjects with the more extreme values for this ratio were selected to form the 2 study groups. Group I comprised 35 subjects with a horizontal facial growth pattern (16 male, 19 female, aged 14.08 ± 3.10 years [mean ± standard deviation]), exhibiting a proportionally short lower anterior face height, and group II comprised 35 subjects with a vertical facial growth pattern (15 male, 20 female, aged 13.95 ± 2.41 years, 19 with Class II Division 1 malocclusions and 16 with Class I malocclusions), with a proportionally long lower anterior face height (Table I).

The following landmarks were identified on the lateral cephalometric tracings (Fig 1):
- Menton (Me): the lowest point of the mandibular symphysis
- Anterior nasal spine (ANS): the tip of the anterior nasal spine
- Nasion (N): the anterior end of the nasofrontal suture

The following linear measurements were obtained (Fig 1):
- Upper anterior face height (UAFH): the distance between N and ANS (N-ANS)
- Lower anterior face height (LAFH): the distance between ANS and Me (ANS-Me)

The 140 dental study models (maxillary and mandibular pretreatment dental study models from the 70 subjects) were duplicated with alginate and poured with classic orthodontic stone. The posterior occlusal plane (POP) was determined by a rectangular piece of glass seated on at least 3 selected points: 1 at the most prominent cusp of each first mandibular molar and 1 or 2 at the most prominent cusp of the second premolars, according to the method described by Ross et al (Fig 2). The base of the models was trimmed parallel to the POP.

Sequentially, the dental study models were divided into right and left halves through the P cut (Fig 3). The distal portions of each side were then trimmed perpendicularly to their base (and to the POP) up to the occlusal lines (A and B cuts) that pass through the mesiobuccal and mesiolingual cusps of the first molars (Fig 3). The mesial portions of each side were also trimmed perpendicularly to their base and up to the

Table I. Upper to lower anterior face height relationships and ages for group I (horizontal growth pattern) and group II (vertical growth pattern)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
<th>UAFH/LAFH minimum</th>
<th>UAFH/LAFH maximum</th>
<th>Age (years) Mean (SD)</th>
<th>Range (years)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>35</td>
<td>16</td>
<td>19</td>
<td>0.800</td>
<td>0.966</td>
<td>14.08 (3.10)</td>
<td>11.33–29.33</td>
<td>.83787</td>
</tr>
<tr>
<td>Group II</td>
<td>35</td>
<td>15</td>
<td>20</td>
<td>0.544</td>
<td>0.693</td>
<td>13.95 (2.41)</td>
<td>10.08–20.58</td>
<td></td>
</tr>
</tbody>
</table>

Fig 1. Landmarks: nasion (N), anterior nasal spine (ANS), and menton (Me). Linear distances: upper anterior face height (UAFH) and lower anterior face height (LAFH).
occlusal lines (C and D cuts) that pass through the buccal and lingual cusps (mesiolingual cusp for the mandibular teeth) of the second premolars (Fig 3). Independent photocopies of the study models were obtained for each quadrant, from the cuts of the first molar and second premolar from both right and left sides, to determine the planes and angles of interest. Photocopies from partially erupted teeth or teeth with significant rotation were rejected.

The landmarks were then digitized (Hipad DT-11 digitizer, Houston Instruments, Houston, Tex) into a personal computer and analyzed with Dentofacial Planner 7.0 software (Dentofacial Planner Software, Toronto, Ontario, Canada). The occlusal surface of each first molar was represented by a line connecting the mesiobuccal and mesiolingual cusp tips (Fig 4). Similarly, the occlusal surface of the second premolar was represented by a line connecting the buccal and lingual cusp tips. The long axis of each molar and each premolar was represented by a perpendicular line to the occlusal surface. The M point was obtained by the intersection of the tooth long axis and the dental study model base, from which a line perpendicular to the base was drawn (I line). Therefore, the $\theta$ angle was obtained between this line and the tooth long axis; it indicated the buccolingual inclination of the occlusal surface of the first molars and second premolars. The $\theta$ angle was positive when the long axes of these teeth (as obtained from the occlusal surfaces) had a buccal inclination, and negative in cases of lingual inclination.

Because the complete hypothesis for this study was that subjects with long lower anterior face heights have posterior teeth with greater buccal inclinations and longer functional lingual cusps, and conversely, subjects with short lower anterior face heights have a
greater lingual inclinations of the posterior teeth and longer buccal cusps, it was decided that assessing the occlusal heights of the posterior teeth would help to elucidate this matter. Therefore, measurements of the buccal, palatal, and lingual cusp heights were made. These measurements were made from the cusp tip to the gingival crest on the dental study models, parallel to the crown long axis, with a caliper (Mitutoyo America, Aurora, Ill).

**Statistical analysis**

Fourteen cases were randomly selected and remeasured after a 2-month interval. The casual error was calculated according to Dahlberg’s formula:

\[ S^2 = \frac{\sum d^2}{2n} \]

where \( S^2 \) is the error variance and \( d \) is the difference between the 2 determinations of the same variable; and the systematic error was determined by dependent \( t \) test, for \( P < .05 \).

Means and standard deviations for each variable were calculated to enable characterization of both groups that were compared by \( t \) test. A \( P \) value of less than .05 was considered significant. The groups’ ages were compared to determine their compatibility. For statistical purposes, the teeth were divided into 4 categories to assess tooth inclination: maxillary first molars, maxillary second premolars, mandibular first molars, and mandibular second premolars. For assessing occlusal cusp heights, 8 categories were used: buccal and palatal cusps of the maxillary first molars (BMxM and PMxM), buccal and palatal cusps of the maxillary second premolars (BMxPM and PMxPM), buccal and lingual cusps of the mandibular first molars (BMDM and LMDM), and buccal and lingual cusps of the mandibular second premolars (BMDPM and LMDPM). Each tooth category corresponded to the mean of the right- and left-side teeth.

**RESULTS**

None of the variables had statistically significant systematic errors, and the range of casual errors varied from 0.645° to 1.083°. There was no statistically significant difference between the ages of the groups. The maxillary posterior teeth of subjects with a vertical growth pattern (group II) had a significantly greater buccal inclination compared with those of subjects with a horizontal growth pattern (group I) (Table II). However, the mandibular posterior teeth inclination was not statistically different between groups I and II (\( P < .05 \)), as shown in Table II. The maxillary palatal cusp height of group I was statistically greater than that of group II; no other significant difference was observed regarding intergroup cusp heights (Table III).

**DISCUSSION**

Fields et al demonstrated that vertical facial proportions can be clinically identified, and therefore the initial sample selection could be performed through facial examination. Final sample selection was defined on the basis of the cephalometric proportion of the upper to lower anterior face height, because facial proportions are more important than absolute values in the analysis of vertical discrepancies. Additionally, this reduces the errors introduced by variations in size.

Anterior open bite was not a selection criterion for the excessive LAFH group because anterior open bite is not necessarily associated with long face. When people with excessive LAFH and associated open bite were compared with those having excessive LAFH without associated open bite, the former had smaller mandibular ramus and posterior face heights. Therefore, there were no differences in the anterior face measurements between these groups, as used in this study. Subjects with Class II Division 2 malocclusions have increased upper anterior face heights and consequently increased UAFH/LAFH ratios. On the other hand, patients with long face and open bite usually have vertical growth patterns, associated with an excessive

### Table II. Results of Student \( t \) test between group I (horizontal growth pattern) and group II (vertical growth pattern), for tooth inclination

<table>
<thead>
<tr>
<th>Tooth</th>
<th>Group I Mean (SD)</th>
<th>Group II Mean (SD)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxillary molar</td>
<td>5.13 (4.46)</td>
<td>7.74 (4.41)</td>
<td>.017</td>
</tr>
<tr>
<td>Maxillary premolar</td>
<td>-2.66 (7.13)</td>
<td>0.66 (5.74)</td>
<td>.035</td>
</tr>
<tr>
<td>Mandibular molar</td>
<td>-7.03 (5.11)</td>
<td>-8.03 (4.97)</td>
<td>.408</td>
</tr>
<tr>
<td>Mandibular premolar</td>
<td>-16.51 (7.16)</td>
<td>-18.51 (8.63)</td>
<td>.312</td>
</tr>
</tbody>
</table>

### Table III. Results of Student \( t \) test between group I (horizontal growth pattern) and group II (vertical growth pattern), for cusp heights

<table>
<thead>
<tr>
<th>Tooth</th>
<th>Group I Mean (SD)</th>
<th>Group II Mean (SD)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMxM</td>
<td>4.83 (0.69)</td>
<td>5.18 (0.88)</td>
<td>.073</td>
</tr>
<tr>
<td>PMxM</td>
<td>6.06 (0.75)</td>
<td>5.63 (0.64)</td>
<td>.013</td>
</tr>
<tr>
<td>BMxPM</td>
<td>5.60 (0.68)</td>
<td>5.99 (1.01)</td>
<td>.065</td>
</tr>
<tr>
<td>PMxPM</td>
<td>4.95 (0.72)</td>
<td>4.65 (0.78)</td>
<td>.110</td>
</tr>
<tr>
<td>BMDM</td>
<td>5.66 (0.52)</td>
<td>5.44 (0.75)</td>
<td>.157</td>
</tr>
<tr>
<td>LMDM</td>
<td>4.14 (0.55)</td>
<td>4.28 (0.54)</td>
<td>.280</td>
</tr>
<tr>
<td>BMdPM</td>
<td>6.07 (0.70)</td>
<td>6.12 (1.01)</td>
<td>.833</td>
</tr>
<tr>
<td>LMDPM</td>
<td>3.68 (0.67)</td>
<td>3.77 (0.66)</td>
<td>.582</td>
</tr>
</tbody>
</table>
lower anterior face heights, and decreased UAFH/LAFH ratios.\textsuperscript{2}

The methodology for the posterior teeth inclination evaluation was similar to that used by Ross et al.\textsuperscript{16} In fact, the measured angle does not correspond to the actual long axis inclination of the teeth but, rather, to the occlusal surface inclination, as evaluated by connecting a line between the mesiobuccal and mesiolingual cusp tips of the posterior teeth. Thus, extrapolation of the results of the occlusal surface inclination to the long axis inclination between different tooth category averages cannot be performed, because of the different dental crown anatomies. However, in each category, it is possible to extrapolate the results of the occlusal surface inclination to the long axis inclination between groups. Therefore, for example, it is not possible to state that the mandibular second premolar long axis in group II (–18.51\textdegree) is more linguually inclined (not significantly) than the mandibular first molar long axis in the same group (–8.03\textdegree). However, this can be stated in relation to the mandibular second premolar in group I (–16.51\textdegree).

Parallelism between the POP and the study model base was less critical because of the use of the mean between the right and left occlusal surface angulations. This is because the angles are determined in relation to a common reference line; thus, a possible increase in 1 angle due to an inclination of the model base would be reflected in a decrease of the other correspondent angle, to a certain extent compensating the mean.

Comparisons of the current results with those from other studies must be carefully conducted because of differences in sample selection and measurement techniques. The maxillary molars and premolars of subjects with a vertical pattern had a statistically significant greater buccal inclination than those in subjects with a horizontal pattern (Table II). Ross et al\textsuperscript{16} compared the inclination of the occlusal surface of first molars in subjects with different growth patterns (26° \(\geq\) SN.GoGn \(\geq\) 38°) and did not find statistically significant differences. However, the maxillary teeth of those with a vertical growth pattern had a statistically significant lingual inclination of the posterior teeth in relation to the posterior teeth of subjects with horizontal patterns. This contrasts with the tendency found by Ross et al\textsuperscript{16} for these teeth and also with the statistically significant differences found by Tsunori et al.\textsuperscript{17} These last authors had small group sizes for the short and long facial types (9 and 7, respectively). Perhaps these represented the extremes of each type, and consequently the difference was evidenced. Thus, there might be a difference in mandibular posterior tooth inclination between these facial patterns, but it seems to be smaller than for the inclination of the maxillary posterior teeth. Comparing the subjects with the most extreme facial types in this study showed a tendency for the differences to increase for the maxillary posterior teeth. Nevertheless, the trend for the mandibular posterior teeth was for maintaining inclination similarity between the groups. Further investigations with extreme facial types should be conducted to clarify this issue concerning the mandibular teeth and to confirm the results for the maxillary teeth.

The complementary evaluation of the occlusal tooth heights showed only a statistically significant difference for the first molars’ palatal cusp height between the 2 groups (Table III). The subjects with horizontal patterns had larger palatal-cusp occlusal height than did those with vertical patterns. This result contrasted with previous suggestions that subjects with long lower anterior face height have posterior teeth with greater buccal inclinations and longer functional lingual cusps.\textsuperscript{11,12,14,15} Similarly, the expectation that subjects with short lower anterior face height have greater lingual inclinations of the posterior teeth and longer buccal cusps\textsuperscript{11,12,14,15} was not confirmed by this complementary evaluation. Therefore, buccolingual tooth inclination does not seem to be related to height of the functional cusps, as previously expected. Although the posterior dentoalveolar heights (measured from the palatal or mandibular plane to the maxillary or mandibular first molar cusp tips) are greater in subjects with vertical patterns than with horizontal patterns,\textsuperscript{14,18,19} this is not the case with the buccal, palatal, and lingual cusp heights.

The hypothesis suggested in the literature,\textsuperscript{11,12,14,15} that subjects with vertical skeletal growth patterns would have posterior teeth with greater buccal inclinations than subjects with horizontal growth patterns, was observed only for the maxillary teeth. Although long-face subjects have a narrower dental arch, the maxillary posterior teeth have a greater buccal inclination than in
short-face people. According to Tsunori et al., even though long-face subjects have a similar tongue size, narrowing of the arches in this facial type allows a greater tongue action on the mandibular posterior teeth, tipping them buccally. A similar action could also take place in the maxillary arch. Additionally, the smaller masticatory muscle force and transversal muscle area of this facial pattern contribute to this situation. The results of this study did not support the hypothesis for the mandibular posterior teeth.

Clinical implications

When there is a severe discrepancy between dental and bone sizes, extraction of permanent teeth is usually indicated. However, slight-to-moderate discrepancies between dental and bone sizes can be corrected through reducing dental structures by interproximal stripping, expanding the dental arch, or a combination of both. Therefore, when slight or moderate crowding is associated with a narrow dental arch and not with an increased dental size, procedures to increase arch dimensions might be considered, to avoid the need for extractions. The suggestion of Howe et al. to treat borderline patients with palatal expansion and buccal inclination of the mandibular posterior teeth, is especially applicable for those with horizontal facial patterns, as compared with those with vertical growth patterns. A common collateral effect of maxillary expansion is buccal tipping of the maxillary posterior teeth. Therefore, because of the greater palatal inclination of the maxillary posterior teeth in this facial pattern, a greater maxillary expansion could be carried out without causing an accentuated and unfavorable buccal tipping of the posterior teeth, which could lead to a greater relapse of the expansion. Consequently, the greater the maxillary expansion performed, the greater the amount of space available to correct the crowding. On the other hand, through this procedure, the mandibular teeth will be further buccally tipped; this might be an unfavorable positioning of the teeth. However, it is possible to maintain this buccal inclination by intercuspation between the mandibular and maxillary teeth, which have greater stability after rapid palatal expansion. Although the current results did not demonstrate a greater lingual inclination of the mandibular posterior teeth in subjects with horizontal growth patterns, others have demonstrated it. Additionally, besides obtaining space from the buccal inclination of the mandibular posterior teeth, these subjects can also tolerate greater mandibular incisor protrusion, which can help correct mandibular crowding.

Conversely, these results suggest the need for closer attention when the above-mentioned procedure is indicated for borderline cases with strong vertical patterns. Extractions usually have more favorable results in this facial type, and nonsurgical palatal expansion can accentuate the buccal inclination of the maxillary posterior teeth, thus jeopardizing maxillary expansion stability (surgically assisted palatal expansion would have fewer collateral effects in these aspects). The same rationale is valid for the mandibular posterior teeth, because there were no statistically significant differences between the groups in this study and because Tsunori et al. demonstrated a greater buccal inclination of the mandibular posterior teeth in this facial type. Another stronger restriction to the nonextraction treatment of borderline cases with vertical patterns is that any protrusion of the mandibular incisors will worsen the profile, because lip incompetence is another characteristic associated with this facial type. Height of the posterior tooth cusps does not seem to be a restrictive factor for the procedure in vertical pattern borderline cases. However, as already emphasized, further studies are necessary to confirm these tendencies in the different facial growth patterns.

CONCLUSIONS

According to the methodology of this study, the following conclusions can be made:

- The maxillary posterior teeth in subjects with vertical growth patterns have a statistically significantly greater buccal inclination as compared with those with horizontal growth patterns.
- No statistically significant differences in the inclination of the mandibular posterior teeth could be found between the 2 groups.

REFERENCES

7. McLaughlin R, Bennett J. The extraction-nonextraction dilemma as it relates to TMD. Angle Orthod 1995;65:175-86.