INTRODUCTION
Orthodontic treatment aims to improve function, balance and esthetics among various structural components of the stomatognathic system, however, enhancement of the facial and dental esthetics is the main reason for patients considering the orthodontic consultation. Beautiful and attractive face has an added advantage in the life of an individual starting from the birth. Smile is the most important aspect assessed by the perceiver during any face to face interaction and maxillary anteriors are the prominent and dominant teeth appreciated during smile. Hence, orthodontists or the esthetic dentists have been reeling on size, shape, proportion of maxillary anterior teeth with the aim of enhancing the smile esthetics which further contributes to the overall beauty of an individual.

Golden proportion is a constant ratio of 1.618:1 which is widely observed in nature and has been found to be pleasing to the human eyes. With the introduction of golden proportion in dentistry, it was proposed in estimating the apparent dimension of maxillary anterior teeth when viewed from the...
However, the literature witnesses a continuous wide debate regarding the ideal perceived tooth to tooth ratio for enhancing esthetic smile.\(^4\) - \(^7\) This ratio has been found to vary with race, gender, and ethnicity.\(^8\) - \(^10\) In considering the factors affecting this perceived esthetic ratio, the vertical dimension of the face and malocclusion type has been given less importance. Hence, this study was carried out with the aim of assessing the apparent tooth to tooth proportion of maxillary anterior region and finding out the possible association with lower anterior facial height and malocclusion type.

**MATERIALS AND METHODS**

This study was started after obtaining the ethical clearance from Nepal Health Research Council. For the sample size calculation, the assumptions made were: confidence level of 95\%, significance level of 0.05, statistical power of 95\%, and smallest relevant difference of 0.01mm and the estimated standard deviation of 0.17. The standardized difference was calculated as the ratio of smallest relevant difference to the estimated standard deviation which was 0.58. Using Altmann nomogram, the sample size would be approximately 150. Hence, 160 samples were chosen for this study with equal number of males and females.

The study was conducted in the Department of Orthodontics, B.P.Koirala Institute of Health Sciences, Dharan, Nepal. All the patients with well aligned maxillary anteriors and all the permanent teeth present till second molars were included. However, patients with prior orthodontic or restorative treatment of maxillary anteriors, attrited or fractured anteriors, gingival inflammation or recession involving the labial surface were excluded.

After obtaining the informed consent from the participants, the lower anterior facial height (LAFH) was measured from subnasale to the lower border of the soft tissue chin with the help of digital Vernier caliper with the accuracy upto 0.01mm (Mitutoyo: CD-8” CS, Japan). Intra-oral examination was done to find out the molar relationship. Molar relationship was classified into Class I, Class II and Class III. Further, intra-oral frontal photograph was made with Nikon D5100 camera with the patient lying comfortably in the dental chair and the soft tissues retracted with the two photographic plastic retractors. During the photography, patient’s head was kept straight with the coronal plane perpendicular to the long axis of the lens of camera to avoid the effect of rotation on the photographic dimension.\(^11\)

The photograph obtained was transferred to a computer and the measurements made with the Image J (1.49) software (freely available at http://imagej.nih.gov/ij/) (Table 1). Data obtained from the measurements were uploaded in Microsoft Excel 2013 and further to SPSS version 20 for statistical analysis. All the measurements were made by a single investigator (RG).

**RESULTS**

This study involved participation of 160 subjects (80 in each sex). The mean age of the sample was $21.51 \pm 2.78$ years with a range of 12 to 25 years. Most of them had Class I molar relationship followed by Class II and Class III (Figure 1). The distribution of the ratio of the apparent mesiodistal tooth width was evaluated with Shapiro Wilk test. The p-values were above the level of 0.05 indicating the normal distribution of these variables.

![Figure 1. Distribution of the molar relationship](image-url)
Two weeks later, 32 (20%) samples were selected randomly and the measurements of LAFH, and apparent mesiodistal width of maxillary anteriors were remade. The ICC (Intra-class correlation coefficient) of these measurements confirmed excellent intrarater reliability (Table 2). The reliability of reassessment of malocclusion class was confirmed by Kappa which showed good reliability (k= 0.844).

The ratio between lateral to central incisor and canine to lateral incisor was compared between right and left side. The paired t-test showed no significant difference between the right and left side for both R1 and R2 (Table 3). Hence, mean of right and left side was calculated and subjected to further statistical analysis. The mean R1 and R2 were 0.68 ± 0.06 and 0.76 ± 0.12 respectively.

LAFH, Mean R1 and R2 were compared between the two sexes using independent sample t-test and no statistically significant differences were found between the two sexes in R1 and R2. However, lower anterior facial height showed a significant difference between male and female (Table 4).

One sample t-test was done to check whether the R1 and R2 was statistically different from the ideal golden ratio i.e. 0.618, and the result showed that the sample ratio was significantly different from the golden ratio, t(159)=12.084, p=0.000 and t(159) =13.987, p=0.000 respectively.

Further, the correlation of R1 and R2 was assessed with lower anterior facial height. The correlation coefficient was -0.004 and 0.000 for R1 and R2 respectively showing negligible correlation. The scatterplot also proves no linear relationship (Figure 2 and 3).

One-way ANOVA was performed to check whether R1 and R2 vary across various groups of malocclusion. It was found that there was no statistically significant difference in the ratios among various malocclusion types (Table 5).

**DISCUSSION**

This study was undertaken with the aim of assessing the microesthetic features of maxillary anterior dentition and finding its association with lower anterior facial height and malocclusion type. Most of the samples had Class I molar relation followed by Class II and Class III. The epidemiological studies exploring malocclusion in Nepalese also found increased prevalence of Class I

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**Table 2. Intraclass correlation coefficient of remeasured parameters.**

<table>
<thead>
<tr>
<th>Re-measured variables</th>
<th>LAFH</th>
<th>MD13</th>
<th>MD 12</th>
<th>MD 11</th>
<th>MD 21</th>
<th>MD 22</th>
<th>MD 23</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICC</td>
<td>0.987</td>
<td>0.916</td>
<td>0.917</td>
<td>0.932</td>
<td>0.902</td>
<td>0.967</td>
<td>0.950</td>
</tr>
</tbody>
</table>

**Table 3. Paired t-test for comparison of Mean R1 and R2 between left and right side**

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Right side</th>
<th>Left side</th>
<th>Mean Diff</th>
<th>95% CI</th>
<th>t</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean R1</td>
<td>0.681</td>
<td>0.677</td>
<td>-0.003</td>
<td>-0.009 to 0.016</td>
<td>0.582</td>
<td>0.561</td>
</tr>
<tr>
<td>Mean R2</td>
<td>0.757</td>
<td>0.756</td>
<td>-0.034</td>
<td>0.022 to -0.024</td>
<td>0.097</td>
<td>0.923</td>
</tr>
</tbody>
</table>

**Table 4. LAFH, mean R1 and mean R2 comparison between male and female**

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Male</th>
<th>Female</th>
<th>Mean Diff</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean R1</td>
<td>0.68</td>
<td>0.68</td>
<td>-0.003</td>
<td>-0.024 to 0.016</td>
<td>0.708</td>
</tr>
<tr>
<td>Mean R2</td>
<td>0.77</td>
<td>0.74</td>
<td>-0.034</td>
<td>0.019 to -0.004</td>
<td>0.078</td>
</tr>
</tbody>
</table>
Table 5. ANOVA for comparison of R1 and R2 across the malocclusion types

<table>
<thead>
<tr>
<th>Ratios</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
<th>F</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>0.682</td>
<td>0.067</td>
<td>0.669</td>
<td>0.052</td>
<td>0.682</td>
</tr>
<tr>
<td>R2</td>
<td>0.757</td>
<td>0.127</td>
<td>0.738</td>
<td>0.121</td>
<td>0.805</td>
</tr>
</tbody>
</table>

Figure 2. Scatterplot demonstrating the relationship between lower anterior facial height and ratio of maxillary lateral to central incisor

Figure 3. Scatterplot demonstrating the relationship between lower anterior facial height and ratio of maxillary canine to lateral incisor

Table 6. R1 and R2 across various population

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>R1</th>
<th>R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandeep et al²⁹</td>
<td>South Indians</td>
<td>0.67 (male)</td>
<td>0.744 (male)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.703 (female)</td>
<td>0.714 (female)</td>
</tr>
<tr>
<td>Hasanreisoglu et al³⁰</td>
<td>Turkish</td>
<td>0.66 (male)</td>
<td>0.80 (male)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.65 (female)</td>
<td>0.79 (female)</td>
</tr>
<tr>
<td>Condon et al¹⁷</td>
<td>Irish</td>
<td>0.65</td>
<td>0.89</td>
</tr>
<tr>
<td>Agrawal et al²⁷</td>
<td>Indians</td>
<td>0.72</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Chinese</td>
<td>0.738</td>
<td>0.748</td>
</tr>
<tr>
<td></td>
<td>Indian</td>
<td>0.710</td>
<td>0.801</td>
</tr>
<tr>
<td></td>
<td>Malay</td>
<td>0.744</td>
<td>0.786</td>
</tr>
<tr>
<td>Kanaparthy et al¹⁰</td>
<td>Saudi</td>
<td>0.689 (male)</td>
<td>0.626 (female)</td>
</tr>
<tr>
<td>Gyawali and Singh (this study)</td>
<td>Nepalese</td>
<td>0.68 (male)</td>
<td>0.68 (female)</td>
</tr>
</tbody>
</table>
malocclusion followed by Class II and III;\textsuperscript{12-15} and hence it was quite common for such distribution in this study sample.

No significant difference in R1 and R2 was found when compared between the two sides and the gender. This is similar to the results obtained in Iranian students,\textsuperscript{4, 16} and Irish students.\textsuperscript{17} Several odontometric studies also suggested that tooth size don’t vary between the sides.\textsuperscript{18-20} Similarly, ethnicity has been found to play no role in the tooth proportion.\textsuperscript{6} This study showed that males tend to have long lower facial height as compared to female which is supported by similar findings in Turkish,\textsuperscript{21} White,\textsuperscript{22} Iraqis,\textsuperscript{23} Central Indians,\textsuperscript{24} North Indians\textsuperscript{25} and South Indians.\textsuperscript{26}

Golden ratio has been widely studied in dentistry and it is believed that this ratio exists between maxillary lateral to central incisor and canine to lateral incisor. The ratios – R1 and R2 in our sample deviated significantly from the well-established golden ratio. Several studies also revealed the non-existence of golden proportion in the tooth to tooth ratio of maxillary anterior teeth (table 6).\textsuperscript{4, 6, 27}

Photographic study in Iranian students confirmed presence of golden ratio in R1 and R2 in only 25% and 2.1% of the samples respectively.\textsuperscript{16} Similarly, golden proportion existed only in 14 to 25% of dental students of Asian origin.\textsuperscript{8} However, Kanaparthi et al found that R2 in male and R1 in female correspond to the golden ratio whereas R1 in male and R2 in female do not.\textsuperscript{10} Golden proportion was found only in R1 in 17% of samples from University of North Carolina.\textsuperscript{32} Similarly, Iranian dental students showed existence of golden proportion only in R1 but not in R2.\textsuperscript{17}

The mesiodistal dimension of maxillary anteriors has been positively correlated with the bizygomatic width, inter-pupillary distance, inter-alar distance, inter-canthal distance, intercommisural width. Further, a ratio was proposed to calculate the height of maxillary central incisor from the facial height.\textsuperscript{33}

In this study, the absolute dimensions of individual teeth were not considered but rather the tooth-to-tooth ratio was analyzed. The result showed negligible correlation of R1 and R2 with lower anterior facial height. Besides, the R1 and R2 across various malocclusion group did not show any significant difference.

**CONCLUSION**

- The ratio of maxillary lateral to central incisor and canine to lateral incisor was found to be 0.68 and 0.76 respectively with no statistically significant difference between the sides and sex.
- The lower anterior facial height in male (mean of 64.60 mm ± 5.69) was statistically greater than female (mean of 61.04 ± 4.79).
- The ratios R1 and R2 do not correspond with the golden ratio and has no association with lower anterior facial height and malocclusion type.

**REFERENCES**