Sagittal Jaw Relationship of Different Types of Cleft and Non-cleft Individuals

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To investigate whether the craniofacial sagittal jaw relationship in patients with non-syndromic cleft differed from non-cleft (NC) individuals by artificial intelligence (A.I.)-driven lateral cephalometric (Late. Ceph.) analysis. The study group comprised 123 subjects with different types of clefts including 29 = BCLP (bilateral cleft lip and palate), 41 = UCLP (unilateral cleft lip and palate), 9 = UCLA (unilateral cleft lip and alveolus), 13 = UCL (unilateral cleft lip) and NC = 31. The mean age was 14.77 years. SNA, SNB, ANB angle and Wits appraisal was measured in lateral cephalogram using a new innovative A.I driven Webceph software. Two-way ANOVA and multiple-comparison statistics tests were applied to see the differences between gender and among different types of clefts vs. NC individuals. A significant decrease (p < 0.005) in SNA, ANB, Wits appraisal was observed in different types of clefts vs. NC individuals. SNB (p > 0.005) showed insignificant variables in relation to type of clefts. No significant difference was also found in terms of gender in relation to any type of clefts and NC group. The present study advocates a decrease in sagittal development (SNA, ANB and Wits appraisal) in different types of cleft compared to NC individuals.

**Keywords**: sagittal jaw relationship, cleft lip and palate, cephalometric analysis, wits appraisal, SNA angle, SNB angle, ANB angle, artificial intelligence

**INTRODUCTION**

Cleft lip and palate; the second most common developmental abnormalities which extant during birth by presenting anatomical alteration of the lip and/or palate (1). This craniofacial malformation is caused by the effects of both genetic and environmental factors such as maternal smoking and alcohol consumption, stress, viral infection during the first 8 weeks of pregnancy, teratogenic drug etc. (2).

The treatment of cleft lip and palate (CLP) is multidisciplinary where the only purpose is to restore the functional and aesthetic value. Many beneficial approaches have been carried out previously such as: dental arch relationship (3), arch dimension (4), tooth size morphometry (5) and craniofacial morphology (6) to evaluate the outcome of CLP patients.

Atypical sagittal growth of maxilla is a common manifestation in patients with UCLP; acknowledged by many researchers yet all of them came to an understanding that the growth and
TABLE 1 | The angular and linear cephalometric measurements with description.

| Measurements                      | Description                                                                 |
|-----------------------------------|-----------------------------------------------------------------------------|
| SNA (The sella-nasion-A point)    | An angle relates to the antero-posterior position of the maxillary apical base to a line passing through the anterior cranial base. |
| SNB (The sella-nasion-B point)    | An angle relates to the antero-posterior position of the mandibular apical base to a line passing through the anterior cranial base. |
| ANB (A point- nasion-B Point)     | An angle relates to the antero-posterior relationship of the mandible to the maxilla. |
| Wits appraisal                    | A linear cephalometric analytic obtained by projecting straight lines from the A and B points, respectively, unto the functional occlusal plane at 90° and measuring the horizontal distance from point AO to BO. |

TABLE 2 | Sagittal analysis—SNA: Gender, Types of Cleft and Gender times types of cleft two-way ANOVA analysis results.

| Gender Type | Mean SD | Cleft Type | Mean | Multiple comparison | MD SE | p-value | 95% CI Lower bound | Upper bound |
|-------------|---------|------------|------|---------------------|-------|---------|-------------------|-------------|
| Male NC     | 79.296  | 3.306      | NC   | 79.796              | NC vs BCLP 4.841* | 1.108 | 0.000 | 2.646 7.036 |
| BCLP        | 74.654  | 4.346      | BCLP | 74.953              | vs UCLP 3.637* | 0.961 | 0.000 | 1.733 5.541 |
| UCLP        | 76.267  | 4.751      | UCLP | 76.158              | vs UCL 0.352 | 1.335 | 0.792 | −2.293 2.997 |
| UCL          | 77.709  | 3.887      | UCL  | 79.443              | vs UCLA 1.752 | 1.598 | 0.275 | −1.414 4.918 |
| UCLA        | 78.542  | 3.424      | UCLA | 78.042              | BCLP vs UCLP −1.204 | 1.046 | 0.252 | −3.277 0.869 |
| Total Male  | 76.735  | 4.429      |       |                     |       |        |                   |             |
| Female NC   | 80.294  | 3.641      | NC   | 79.796              | NC vs UCLA −7.026* | 1.704 | 0.001 | −11.905 −2.146 |
| BCLP        | 75.253  | 2.303      | BCLP | 74.953              | vs UCL −4.489* | 1.398 | 0.002 | −7.258 −1.720 |
| UCLP        | 76.049  | 4.170      | UCLP | 76.158              | vs UCL −3.285* | 1.284 | 0.012 | −5.830 −0.740 |
| UCL          | 81.177  | 5.072      | UCL  | 79.443              | vs UCLA −1.885 | 1.556 | 0.228 | −4.968 1.198 |
| UCLA        | 77.543  | 1.139      | UCLA | 78.042              | BCLP vs UCLA 1.400 | 1.811 | 0.441 | −2.188 4.988 |
| Total Female | 77.920  | 4.339      |       |                     |       |        |                   |             |
| Total NC    | 79.843  | 3.473      |       |                     |       |        |                   |             |

SD, standard deviation; MD, mean difference; SE, standard error; CI, confidence interval; PES, partial eta square. * = Significant difference.

direction of the jaw utterly influenced by the earlier treatment protocol such as time and techniques of primary surgeries (7–12). The detrimental effect of palatoplasty on sagittal growth of maxilla has been widely documented in literature (9) but whether cheiloplasty impedes the growth is still in controversy (8, 13). A number of researchers found that cheiloplasty has an effect on maxillary incisors, alveolar bone and development of maxilla as well whether some researchers claimed no effect on maxillary development (7, 11, 12, 14, 15).

The craniofacial characteristics of CLP can be assessed from cephalogram (16) and cone-beam computed tomography (17) as well. Abundant cephalometric studies have been done on CLP yet restricted to three-dimensionally. Artificial intelligence (A.I.) into dentistry, especially in cleft research is still a new-fangled and robust technique (18–21).

Use of A.I driven Webceph software for the measurements of all variables in cephalogram were the particularities from previous study which is more accurate, precise, robust and reliable compared to manual measurements (18–21).

For the first time, the present study tried to disclose the sagittal development of Saudi Arabian CLP patients, by A. I driven lateral cephalometric analysis and compared it with the non-cleft (NC) individuals and also compared in relation to gender and types of cleft.

MATERIALS AND METHODS

This retrospective study was limited to 123 individuals including 29 bilateral cleft lip and palate (BCLP), 41 unilateral cleft lip and palate (UCLP), 13 unilateral cleft lip UCL, 9 unilateral cleft lip and alveolus (UCLA) and 31 NC individuals with the average age of 13.29 [3.52] (NC), 14.07 [4.73] (BCLP), 14.32 [4.46] (UCLP), 12.78 [4.09] (UCLA), and 13.31 [4.46] (UCL) years, respectively. All the data (medical records and
| Gender | Type | Mean | SD  | Cleft type | Mean | Multiple comparison | MD  | SE  | p-value | 95% CI Lower bound | 95% CI Upper bound |
|--------|------|------|-----|------------|------|---------------------|-----|-----|---------|----------------|-----------------|
| Male   | NC   | 75.739 | 3.548 | NC | 76.017 | NC vs BCLP | 0.521 | 1.139 | 0.648   | −1.736 | 2.777           |
|        | BCLP | 74.190 | 5.326 | BCLP | 75.496 | vs UCLP  | −0.214 | 0.988 | 0.829   | −2.171 | 1.744           |
|        | UCLP | 77.032 | 3.368 | UCLP | 76.230 | vs UCL    | −0.615 | 1.372 | 0.655   | −3.334 | 2.104           |
|        | UCL  | 74.916 | 4.630 | UCL  | 76.632 | vs UCLA   | 0.100  | 1.643 | 0.951   | −3.155 | 3.355           |
|        | UCLA | 76.490 | 5.171 | UCLA | 75.917 | BCLP vs UCLP | −0.734 | 1.076 | 0.496   | −2.866 | 1.397           |
| Total  |      | 75.643 | 4.395 |       |       | vs UCL    | −1.136 | 1.437 | 0.431   | −3.983 | 1.711           |
| Female | NC   | 76.295 | 3.111 | NC | 76.017 | NC vs UCLA | −0.421 | 1.697 | 0.805   | −3.783 | 2.942           |
|        | BCLP | 76.803 | 5.139 | BCLP | 76.490 | vs UCL    | −0.402 | 1.321 | 0.762   | −3.018 | 2.215           |
|        | UCLP | 75.429 | 3.497 | UCLP | 75.917 | vs UCLA   | 0.314  | 1.600 | 0.845   | −2.856 | 3.484           |
|        | UCL  | 78.348 | 4.859 | UCL  | 76.632 | UCLA vs BCLP | 1.715  | 1.862 | 0.702   | −2.974 | 4.405           |
| Total  |      | 76.225 | 3.788 |       |       | vs UCLA   | −2.671 | 1.561 | 0.090   | −5.762 | 0.421           |
| Female | NC   | 76.044 | 3.371 | NC | 76.017 | NC vs UCLA | −0.421 | 1.697 | 0.805   | −3.783 | 2.942           |
|        | BCLP | 76.250 | 3.484 | BCLP | 76.490 | vs UCL    | −0.402 | 1.321 | 0.762   | −3.018 | 2.215           |
|        | UCLP | 75.917 | 3.497 | UCLP | 75.917 | vs UCLA   | 0.314  | 1.600 | 0.845   | −2.856 | 3.484           |
|        | UCL  | 78.108 | 4.500 | UCL  | 76.632 | UCLA vs BCLP | 1.715  | 1.862 | 0.702   | −2.974 | 4.405           |
| Total  |      | 75.898 | 4.133 |       |       | vs UCLA   | −2.671 | 1.561 | 0.090   | −5.762 | 0.421           |

**SD**, standard deviation; **MD**, mean difference; **SE**, standard error; **CI**, confidence interval; **PES**, partial eta square. * = Significant difference.

**TABLE 4 | Sagittal analysis—ANB: Gender, Types of Cleft and Gender times types of cleft two-way ANOVA analysis results.**

| Gender | Type | Mean | SD  | Cleft type | Mean | Multiple comparison | MD  | SE  | p-value | 95% CI Lower bound | 95% CI Upper bound |
|--------|------|------|-----|------------|------|---------------------|-----|-----|---------|----------------|-----------------|
| Male   | NC   | 3.556 | 1.800 | NC | 3.778 | NC vs BCLP | 4.321 | 1.047 | 0.000   | 2.247 | 6.396           |
|        | BCLP | 0.465 | 4.604 | BCLP | −0.543 | vs UCLP  | 3.851 | 0.908 | 0.000   | 2.051 | 5.650           |
|        | UCLP | −0.784 | 3.497 | UCLP | −0.073 | vs UCL    | 0.967 | 1.262 | 0.445   | −1.533 | 3.467           |
|        | UCL  | 2.794 | 5.857 | UCL  | 2.811 | vs UCLA   | 1.650 | 1.511 | 0.277   | −1.342 | 4.643           |
|        | UCLA | 2.052 | 4.138 | UCLA | 2.128 | BCLP vs UCLP | −0.470 | 0.989 | 0.635   | −2.430 | 1.489           |
| Total  |      | 1.092 | 4.190 |       |       | vs UCL    | −3.355 | 1.321 | 0.012   | −5.972 | −0.737          |
| Female | NC   | 3.999 | 2.683 | NC | 3.778 | NC vs UCLA | −2.671 | 1.561 | 0.090   | −5.762 | 0.421           |
|        | BCLP | −1.551 | 5.545 | BCLP | −2.884 | vs UCL    | −2.200 | 1.471 | 0.137   | −5.115 | 0.714           |
|        | UCLP | 0.619 | 3.004 | UCLP | −2.200 | vs UCL    | −0.684 | 1.712 | 0.690   | −2.708 | 4.076           |
|        | UCL  | 2.828 | 4.256 | UCL  | 2.828 | vs UCLA   | 0.684  | 1.712 | 0.690   | −2.708 | 4.076           |
| Total  |      | 1.695 | 3.982 |       |       | vs UCLA   | −2.671 | 1.561 | 0.090   | −5.762 | 0.421           |

**SD**, standard deviation; **MD**, mean difference; **SE**, standard error; **CI**, confidence interval; **PES**, partial eta square. * = Significant difference.
TABLE 5 | Sagittal analysis—Witts analysis: Gender, Types of Cleft and Gender times types of cleft two-way ANOVA analysis results.

| Gender | Type | Mean | SD  | Cleft type | Mean | Multiple comparison | MD  | SE | p-value | 95% CI Lower bound | 95% CI Upper bound |
|--------|------|------|-----|-----------|------|---------------------|-----|----|---------|-----------------|-------------------|
| Male   | NC   | 0.831| 2.769| NC        | 0.474| NC vs BCLP          | 3.690*| 1.184| 0.002   | 1.344           | 6.036             |
|        | BCLP | −4.233| 5.479| BCLP      | −3.216| vs UCLP            | 3.073*| 1.027| 0.003   | 1.038           | 5.108             |
|        | UCLP | −3.804| 3.938| UCLP      | −2.599| vs UCL              | 1.110 | 1.427| 0.438   | −1.717          | 3.937             |
|        | UCL  | 0.326| 5.514| UCL       | −0.635| vs UCLA             | 1.543 | 1.708| 0.368   | −1.842          | 4.927             |
|        | UCLA | 0.107| 5.424| UCLA      | −1.068| BCLP vs UCLP        | −0.617| 1.119| 0.582   | −2.833          | 1.599             |
| Female | NC   | 0.117| 3.678| vs UCLA   | −2.581| 1.494               | 0.087| 0.823| 0.003   | −5.541          | 0.379             |
|        | BCLP | −2.199| 5.031| vs UCL    | −1.964| 1.373               | 0.155| 0.756|         | −4.884          | 0.776             |
|        | UCLP | −1.395| 3.878| vs UCLA   | −1.531| 1.663               | 0.359| 1.765|         | −4.826          | 1.765             |
|        | UCL  | −1.597| 3.169| UCL       | −UCLA | −0.433              | 1.936| 0.543| 0.001   | −3.403          | 4.268             |
|        | UCLA | −2.243| 3.425| Total     | −1.107| 3.873               |      |      |         |                 |                   |
| Total  | NC   | 0.440| 3.266| Gender    | 0.909| Gender * cleft type | 0.274| 0.044|         |                 |                   |

SD, standard deviation; MD, mean difference; SE, standard error; CI, confidence interval; PES, partial eta square. * = Significant difference.

RESULTS

Results of SNA Angle

The mean SNA angle of NC, UCLP, BCLP, UCL and UCLA were 79.795°, 76.158°, 74.953°, 79.443°, and 78.042°, respectively. However, no significant differences were found in terms of gender and types of cleft (Table 3).

Results of ANB Angle

The mean ANB angle of NC, UCLP, BCLP, UCL and UCLA were 3.773°, −0.073°, −0.543°, 2.811° and 2.128°, respectively. UCLP (p-value <0.001) and BCLP (p-value <0.001) subjects had significantly smaller ANB angles compared to NC subjects. However, no significant differences were found in terms of gender (Table 4).

Results of Wits Appraisal

The mean dimensions of NC, UCLP, BCLP, UCL and UCLA were 0.474, −2.599, −3.216, −0.635, and −1.068 mm, respectively.

X-rays) of this study were collected from Saudi Board of Dental Residents and approved by the Ethical Committee of Al Rass Dental Research Center, Qassim University (DRC/009FA/20). Non-syndromic cleft individuals with good-quality x-ray images were included whereas any history of craniofacial surgery, bone grafting and orthodontic treatment was excluded from the study. Same age group of healthy non cleft individuals were also included as the control group. Convenient sampling has been done without randomization.

Digital Lateral Cephalogram X-rays were used to measure four different cephalometric parameters (SNA, SNA, ANB and Wits appraisal) to investigate sagittal characteristics of 123 individuals of cleft and non-cleft group. All the cephalometric parameters were measured by one examiner using automated (20, 21) A.I.-driven Webceph software (South Korea). The angular and linear measurements used in this study are detailed in Table 1.
UCLP (p-value 0.003) and BCLP (p-value 0.002) subjects had significantly smaller Wits appraisal compared to NC subjects. However, no significant differences were found in terms of gender.

Table 5 shows the detailed results of Wits appraisal in relation to gender and types of cleft and NC. The profile plot of estimated marginal means of types of cleft and gender∗types of cleft has been shown in Figure 1.

**DISCUSSION**

The prime objective of this paper was to find out and compare the sagittal development among different types of Saudi CLP patients with NC group and also compare it in relation to gender and types of clefts. Even though several researchers were researched on different issues of CLP patients, very few researchers were described on sagittal development of CLP patients. However, no study was documented previously in Saudi population about sagittal development. For the first time, the present work studied the sagittal development among Saudi population exclusively.

In this present study, we measured SNA, SNB, ANB and Wits appraisal of non-syndromic Saudi CLP patients where all the patients completed their primary surgeries (lip surgery and palate surgery) by the first 2 years of life. The maxillofacial growth of a CLP patient is quite convoluted; affected by both congenital and postnatal treatment factors (3). Primary surgeries limited the maxillary growth which leads to maxillary hypoplasia and finally toward Class III malocclusion reported previously (22).

Poor maxillary growth of CLP patients is one of the chief apprehensions of orthodontists for the corrections of the dento-facial discrepancies especially during the period of early adolescence (7). The outcome of the current study may help and support the surgeon to bring out the proper primary surgical techniques and also to the orthodontist to make better treatment
plans for CLP patients. The patient who exhibited smaller SNA, ANB and Wits appraisal specifies the poor maxillary growth may perhaps have need of orthognathic surgery in future for the complete correction of dento-facial divergences (7, 23). Wits appraisal is a supreme linear cephalometric parameter which is used to evaluate and assist an additional information with ANB angle for the assessment of skeletal base discrepancies (24).

In our study we found significant reduction of SNA, ANB and Wits appraisal in cleft individuals compared NC individuals which indicated the maxillofacial growth deficiency. However, SNB was an insignificant variable which is a respectable evidence that cleft does not affect on mandibular growth and coincides with one of the earlier studies (25).

The results of current study also match with the outcome of (26) who assessed 45 lateral cephalograms including both cleft and NC individuals reported significantly decreased SNA and ANB between cleft and NC groups and also did not found any significant difference in SNB angle.

An observational study by Holts et al. (27) using German UCLP, BCLP and NC group showed reduced SNA and ANB angle with minor Class III malocclusion in both UCLP and BCLP groups.

Haque et al. (7) put the idea that Modified Millard techniques of Cheiloplasty and Bardach technique of palatoplasty had noticeable negative effect on anterior segment of maxillae especially on inter canine width by studying maxillary arch dimension of Malaysian UCLP subjects. After analyzing the cephalograms of operated Japanese UCLP subjects, Alam et al. (6, 10) also found altered craniofacial morphology in relation to both postnatal treatment factors and congenital factors.

Lisson et al. (28) compared two centers of German children with BCLP ranging from 10 to 18 years in age: center 1 showed significant reduction of ANB and Wits appraisal and center 2 showed significant reduction of ANB and Wits appraisal and significant increase of SNB angle. The outcome of their study revealed underdeveloped maxilla in both centers even though the time and sequence of palatoplasty was the main difference between the centers.

The present study also paid attention to gender disparities with sagittal jaw relationships, however did not get any significant difference. In an earlier Saudi cleft study by Alam and Alfawzan (20) on dental characteristics, did not find any significant relation with gender. Similar findings also reported in Bangladeshi UCLP children (11). In contrast, interestingly Arshad et al. (12) reported significant gender disparities in relation to treatment outcome among Pakistani UCLP children.

This different result among different populations indicates the racial bias of UCLP subjects.

Although the present study has reached its aim, however, there were some unavoidable limitations. Because of insufficient data from other centers, this study was conducted from a single center. In a future study we plan to do a multi-center study after collection of sufficient data, especially on UCL and UCLA sample from other centers.

CONCLUSION

In this present study, we observed,

- significant reduction of SNA angle in UCLP, BCLP, UCL and UCLA; ANB angle and Wits appraisal in UCLP and BCLP compared to NC group.
- no significant difference in SNB angle in any cleft and NC group.
- no significant gender inequalities in relation to any type of CLP and NC group.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethical Committee of Al Rass Dental Research Center, Qassim University (DRC/009FA/20). Written informed consent to participate in this study was provided by the participants’ legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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