Radiographic Assessment of Craniofacial Morphology and Airway Dimensions of Parents of Cleft Lip and Palate Patients

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ABSTRACT

Objective: To assess and compare maternal and paternal craniofacial morphology and airway dimensions of parents of children with unilateral or bilateral cleft lip and palate (CLP).

Study Design: A cross-sectional study.

Place and Duration of the Study: Department of Orthodontics, the Armed Forces Institute of Dentistry, Rawalpindi, Pakistan, from September 2022 to March 2024.

Methodology: A cross-sectional study was conducted on lateral cephalograms, posterior-anterior cephalograms (PA, Ceph), and orthopantomograms (OPG) of 44 parental pairs of cleft lip and palate patients. Fifteen radiographic variables were used to analyse the craniofacial morphology, dental and soft tissue patterns, and airway dimensions of parents of CLP children. Frequencies and percentages for paternal and maternal skeletal, soft tissue, and dental craniofacial variables as well as airway dimensions of parents were calculated and compared.

Results: The majority of fathers and mothers presented with class I sagittal skeletal pattern with no facial asymmetry and normal maxillary and mandibular lengths and were normodivergent. However, a trend of a relatively greater percentage of increased lower facial height was seen in fathers and decreased lower facial height was seen in mothers. An increased percentage of protrusive upper lip was found in fathers. Dental inclinations were normally inclined in most of the parental pairs. Upper and lower incisor proclination was found in a greater percentage of fathers. Upper incisors were retroclined in a greater percentage of mothers. The airway dimension was normal in the majority of parents, however, percentage of narrowed upper and lower airways was greater in fathers.

Conclusion: Parents of patients with CLP showed craniofacial morphology comparable to norms of the population with some distinct characteristics.

Key Words: *Dentofacial deformity, Condyle, Sella turcica, Facial clefts, Malocclusion*.

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INTRODUCTION

The most common and severe congenital anomaly affecting the orofacial structures is cleft lip and palate (CLP).[1] It can be either isolated or in conjugation with other congenital anomalies or syndromes. The prevalence of CLP is 1.5 per 1,000 live births,[2] with variations observed across different ethnicities and geographic regions. The incidence in Asians is 0.82 to 4.04 per live birth, which is relatively higher in Pakistan at 25.6 in 1,000 crude birth rate.[3] Long-term treatment and multidisciplinary management of cleft palate and lip are required. It is not only psychologically debilitating, but has social as well as physical implications.

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Aetiological factors of CLP are genetic in conjugation with environmental teratogens, depicting a multi-factorial nature. Risk factors include smoking and alcohol consumption, use of certain medicines in pregnancy such as Phenytoin, Benzodiazepines, Sodium Valproate, and Corticosteroids, and conditions such as diabetes and consanguineous marriage.[3] Moreover, syndromes of more than 300 are to be associated with clefting of the orofacial region.[4] Multiple syndromes associated with CPL are Downs, Ectodermal dysplasia, *Van der Voude*, Pierre Robin sequence and *22q* deletion syndromes *etc*. Certain disturbances in the loci of gene and transcription growth factors are also contributing factors towards genetic disturbances, thus causing CLP.[5] These include transcription growth factor alpha, transcription growth *factor Beta-2 and 3*, interferon regulatory *factor-6* and *MSX-1* genes *etc*.

Lip and alveolus cleft results from the failure of fusion of maxillary prominences and medial nasal prominences, while the failure of fusion of palatine shelves results in the cleft palate.[6] Orofacial clefts can be classified as; non-syndromic or

syndromic, unilateral or bilateral, and complete or incomplete. Prenatal diagnosis with the help of ultrasonography and colour Doppler aids in preparing the parents for the upcoming events. Management of CLP involves a multidisciplinary approach. It is aimed at obtaining optimum facial aesthetics, function, growth, and improvement in speech.[7]

Isolated cleft palate is predominant in females, while in males, cleft lip is associated with cleft palate. Isolated cleft palate has a stronger syndromic association and is less common than CLP.[8] Cephalometric studies were employed for drawing a comparison of parental features and for evaluating the correlation between the orofacial cleft and phenotypic presentations within the immediate relatives.

The purpose of this study was to evaluate and compare the craniofacial morphology, dental and soft tissue patterns, and airway dimensions of parents of the orofacial cleft children. The rationale was to assess the trends of skeletal, dental and soft tissue morphology prevalent in parents of cleft children in the Pakistani population. Early prediction and diagnosis of CLP deformity are aided by an understanding of an individual's phenotype and craniofacial features that render them predisposed to having a child with CLP.

METHODOLOGY

This cross-sectional study was conducted at the Armed Forces Institute of Dentistry. The approval of the study was taken from the Institute's Ethical Review Board (Letter Ref. No: 918/168Trg, Dated: 13 May 2020). The sample of this study comprised the parents of babies born with non-syndromic CLP who presented to the Department of Orthodontics and Maxillofacial Surgery, from September 2022 to March 2024. A total of 44 sets of parents (44 mothers and 44 fathers) were selected for the study.

The sample was selected using the non-probability consecutive sampling method and the inclusion criteria were; parents of CLP children who understood and gave consent to participate in the study, both parents should have agreed to contribute radiographic records, falling in the category of mild class I, II, and III malocclusion, having a full set of dentition, and sample records having good quality cephalograms, posterior-anterior cephalograms (Ceph), and orthopantomograms (OPG). The exclusion criterion were set as cases with incomplete records, gross skeletal defect noticed during radiological examinations and severe class II Division 1 and 2, class III, skeletally high angle, and open-bite cases. Patients with multiple missing teeth and crowns and bridges in any part of the maxilla. Long congenital or developmental deformities and any syndrome, either of the parents with progressive deformity in the temporomandibular joint, pregnant mothers, mothers with history of teratogenic medicines intake and parents having a history of trauma, previous orthodontic treatment, or orthognathic surgery were also excluded.

The lateral Ceph and OPG of the participants were acquired with digital cephalostat (Carestream 8000C, model DFBD040, France) while the subjects' heads were positioned in the natural head position. Additional posterior-anterior cephalograms (PA Ceph) were taken only for those parents in whom facial asymmetry was found during radiographic examination. To minimise radiation exposure, participants were exposed to x-ray under strict protocol, and especially for mothers it was ensured that the lead apron with additional neck collar was placed during exposure. The radiation dose was kept at minimal possible recommended level by the British SOP guidelines i.e. 3µSv for lateral and PA Ceph and 30µSv for OPGs.[9]

The lateral Cephs, PA Cephs, and OPGs were traced and analysed, and fifteen variables were measured (Figure 1).[10]

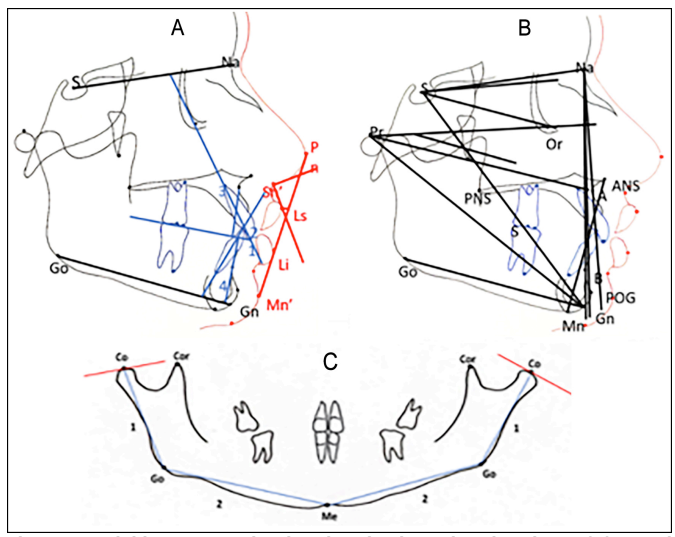

Figure 1: Variables measured and analysed on lateral Ceph and OPG. (A) Dental analysis: Upper incisor to SN plan angle 1) and lower incisor to manibular plane angle 2) soft tissue analysis: Nasolabial angle (Sn'-Ls' tangent to base of nose) upper and lower lip distance from E-line (Pn-Pog). (B) Measurements: SNA angle, SNB angle, ANB angle, Witt's, Naslon perpendicular-point A, Naslon perpendicular-point Pog, effective maxillary length (Co-A), effective mandibular length (Co-Gn) and facial angle (Na-S-Pog). Sella nasion-mandibular plane angle (S-Na<Go-Gn), Frankfurt horiontal (Pr-Or) mandibular plane angle (Go-Gn), maxillo-mandibular plane angel (Go-Gn<ANS-PNS), lower facial height (ANS-Gn). (C) Landmarks: Co-condylion, Cor-coronoid, Go-gonion, Me-mention. Measurements; 1-ramal height, 2-body length.

The shape of sella turcica was labelled according to the classification given by Axelsson *et al*.[11] and the shape of the condyle was classified according to classification by Ribeiro *et al*.[12] Facial asymmetry was evaluated using the Rickett's frontal Ceph analysis.[10] Airway dimensions were measured using the McNamara's analysis. The shape of condyle,[12] ramal heights, and body lengths were evaluated on OPG.

Data were analysed using SPSS version 25.0. To assess the intraobserver variation, ten cephalometric radiographs were randomly selected, and variables were re-measured at two-week intervals by the same observer and assessed using the intraclass correlation coefficient. Frequencies and percentages for gender cleft type and cleft side of cleft patients and mean and standard deviation for age of parents of cleft patients were calculated. Frequencies and percentages for paternal and

maternal skeletal, soft tissue, and dental craniofacial variables as well as airway dimensions of parents were calculated and compared.

RESULTS

A total sample of 44 CLP subjects (28 males and 16 females) were included. Thirty subjects had unilateral CLP (18 right-sided CLP and 12 left-sided CLP), while 14 subjects had bilateral CLP.

Table I: Frequency values and percentages of paternal and maternal skeletal craniofacial variables.

Variables	Fathers of CLP patients	Mothers of CLP patients
Sagittal skeletal pattern		
Class I	28 (63.6%)	35 (79.5%)
Class II	10 (22.7%)	6 (13.6%)
Class III	6 (13.6%)	3 (6.8%)
Facial asymmetry		
Present	3 (6.8%)	4 (9.1%)
Absent	41 (93.2%)	40 (90.9%)
Face divergence		
Normodivergent	35 (79.5%)	36 (81.8%)
Hypodivergent	-	5 (11.4%)
Hyperdivergent	9 (20.5%)	3 (6.8%)
Lower facial height		
Increased	13 (29.5%)	8 (18.2%)
Decreased	1 (2.3%)	4 (9.1%)
Normal	30 (68.2%)	32 (72.7%)
Effective maxillary length		
Increased	1 (2.3%)	1 (2.3%)
Decreased	3 (6.8%)	6 (13.6%)
Normal	40 (90.9%)	37 (84.1%)
Effective mandibular length		
Increased	5 (11.4%)	1 (2.3%)
Decreased	1 (2.3%)	-
Normal	38 (86.4%)	43 (97.7%)
Sella shape		
Normal	42 (95.5%)	39 (88.6%)
Irregular posterior wall	1 (2.3%)	1 (2.3%)
Sella bridge	1 (2.3%)	1 (2.3%)
Oblique anterior wall	-	2 (4.5%)
Double contour of floor	-	1 (2.3%)
Condylar shape		
Round	35 (79.5%)	32 (72.7%)
Convex	9 (20.5%)	11 (25%)
Flat	-	1 (2.3%)

Table II: The frequency values and percentages of paternal and maternal soft tissue, dental and airway dimension variables.

Variables	Fathers of CLP patients	Mothers of CLP patients
Nasolabial angle		
Normal	27 (61.4%)	34 (77.3%)
Acute	14 (31.8%)	10 (22.7%)
Obtuse	3 (6.8%)	-
E-Line to upper lip		
Normal	30 (68.2%)	25 (56.8%)
Protrusive	8 (18.2%)	5 (11.4%)
Retrusive	6 (13.6%)	14 (31.8%)
E-Line to lower lip		
Normal	33 (75.0%)	38 (86.4%)
Protrusive	7 (15.9%)	3 (6.8%)
Retrusive	4 (9.1%)	3 (6.8%)
Upper incisor inclination		
Normal	27 (61.4%)	32 (72.7%)
Proclined	15 (34.1%)	8 (18.2%)
Retroclined	2 (4.5%)	4 (9.1%)
Lower incisor inclination		
Normal	24 (54.5%)	32 (72.7%)
Proclined	16 (36.4%)	8 (18.2%)
Retroclined	4 (9.1%)	4 (9.1%)
Upper airway		
Normal	41 (93.2%)	43 (97.7%)
Narrow	3 (6.8%)	1 (2.3%)
Lower airway		
Normal	37 (84.1%)	41 (93.2%)
Narrow	7 (15.9%)	3 (6.8%)

Father and mother of each subject with CLP i.e. 44 parental pairs were included in the study group. The mean age of fathers was 33.4 ± 6 years with a minimum of 22 and a maximum of 45 years. The mean age of mothers was 30 ± 6 years with a minimum of 19 and a maximum of 41 years.

The majority of fathers and mothers presented with class I sagittal skeletal pattern i.e. 63.6% (n = 28) and 79.5% (n = 35), respectively followed by skeletal class II pattern and the least had class III skeletal pattern. However, on comparing paternal and maternal variables, it was shown that fathers of CLP patients presented with a greater percentage of class II (22.7%, n = 10) and Class III (13.6%, n = 6) sagittal skeletal relationships as compared to mothers (Table I).

Significant facial asymmetry was found in 7 subjects and was found to be slightly more in mothers as compared to fathers i.e. 9.1% (n = 4) and 6.8% (n = 3), respectively, however, most parental pairs had no facial asymmetry.

The majority of CLP patients had normodivergent parents with different trends of vertical facial dimensions in fathers and mothers. Fathers reported with greater percentage of hyperdivergent facial proportions (20.5%, n = 9) as compared to mothers (6.8%, n = 3), whereas mothers reported a greater percentage of hypodivergent vertical facial proportions (11.4%, n = 5) than fathers. A similar trend of a greater percentage of increased lower facial height was seen in fathers (29.5%, n = 13) as compared to mothers (18.2%, n = 8), and a greater percentage of decreased lower facial height was seen in mothers (9.1%, n = 4) as compared to fathers (2.3%, n = 1).

The effective maxillary length was normal in most parental pairs (average 87.5%, n = 38), however, it was reduced in 13.6% (n = 6) of mothers and 6.8% (n = 3) of fathers and increased in only a negligible percentage.

The effective mandibular length was normal in most parental pairs (average 92%, n = 40) and was increased in 11.4% (n = 5) of fathers, however, negligible increase or decrease was reported in mothers.

Sella shape was normal in both fathers and mothers of CLP subjects (92%). A negligible percentage of oblique anterior wall of sella (4.5%), irregularposterior sella wall (2.3%), sella bridge (2.3%), and double contour of sella floor (2.3%), was reported. The condylar shape was round in most parents (76%), followed by the convex shape of the condyle (22%), and negligible frequency (2.3%) of flat-shaped condyles.

The frequency values and percentages of soft tissue craniofacial variables of the study group are reported in Table II. The nasolabial angle was normal in the majority of parents, followed by acute nasolabial angle and the least number of parents had obtuse nasolabial angle. Fathers had a greater percentage of acute (9.1%, n = 14), obtuse (6.8%, n = 3), and nasolabial angle than mothers.

Upper lip prominence in relation to the E-line was found to be normal in most fathers and mothers. An increased percentage

of protrusive upper lip (18.2%, n = 8) was found in fathers, whereas an increased percentage of retrusive upper lip (31.8%, n = 14) was found in mothers.

Lower lip prominence in relation to the E-line was found to be normal in most fathers and mothers. An increased percentage of protrusive and retrusive lower lips (15.9%, n = 7 and 9.1%, n = 4, respectively) was found in fathers than in mothers who showed equal frequency of protrusive and retrusive lower lips.

The frequency values and percentages of dental variables of the study group are presented in Table II. Upper and lower incisors were normally inclined in most parental pairs. Upper and lower incisor proclination was found in a greater percentage of fathers (34.1%, n = 15 and 36.4%, n = 16, respectively). Upper incisors were retroclined in a greater percentage of mothers (9.1%, n = 4) than fathers whereas lower incisors showed equal frequency of retroclination in paternal and maternal groups.

Upper and lower pharyngeal airway dimension was normal in the majority of parents, however, percentage of narrowed upper and lower airways was greater in fathers of CLP patients (6.8%, n = 3 and 15.9%, n = 7, respectively) as compared to mothers (Table II).

DISCUSSION

The aetiology of CLP is a multifactorial phenomenon with the involvement of both genetic and environmental factors. Knowledge of an individual's genotype and phenotype susceptible to having a child with CLP is helpful in early identification and diagnosis of deformity.[13]

The present study assesses craniofacial morphology, dental inclinations, and airway dimensions of parents of unilateral and bilateral CLP patients and compares paternal and maternal variables. To investigate the craniofacial morphology of parents of CLP children, fifteen radiographic variables were measured. The maternal and paternal variables of parents were compared to show trends of skeletal, dental, and soft tissue cephalometric variables as well as airway dimensions.

The majority of parents presented with sagittal skeletal class I relationships without significant facial asymmetry. In cases presenting with skeletal class II and III, there was an increased percentage of fathers than mothers. In parents of CLP patients showing facial asymmetry, there was a higher percentage of mothers than fathers. McIntyre *et al*. reported significant facial asymmetry of the parental craniofacial skeleton of CLP parents.[14]

With regard to the vertical facial dimensions of parents, the majority of the parents were normodivergent. The hyperdivergent group of parents had a greater percentage of fathers, while the hypodivergent group of parents had more percentage of mothers. The same trend followed for lower-facial height being normal in most cases, while cases with increased lower facial height had more percentage of fathers, while cases with decreased lower facial height had more percentage of mothers. This can be explained based on sexual dimorphism of lower facial height with males having slightly larger lower facial heights than females.[15] Study by Weinberg *et al*.[16] has documented prominent flattening of the facial profile, decreased upper facial height, and increased lower facial height in cleft parents.

Maxillary and mandibular lengths were found to be normal in most of the parents. Parents with decreased maxillary length had a greater percentage of mothers. Some percentage of fathers showed increased mandibular length. Increased and decreased maxillary lengths have been reported in parents of cleft children in the literature.[17-19] The mandibular length was reduced in the parental groups studied by Kurisu *et al*.[19] whereas Raghavan *et al*.[18] found the mandibular length to be increased. The variability of these results can be explained by heterogeneity in the aetiology of CLP and study designs.

The shape of sella turcica and temporomandibular condyles were assessed to be normal in paternal and maternal groups. Gender and age-related anatomic variations in the shape of sella turcica have been reported depicting growth-related changes in the shape of sella turcica and hormonal activity of the pituitary gland.[20]

Considering soft tissue factors, the nasolabial angle and position of lips with respect to the E-line were measured. The nasolabial angle was found to be normal in the majority of parents followed by acute and then obtuse nasolabial angle. Fathers showed more variability in nasolabial angle as compared to mothers i.e. greater percentage of acute and obtuse nasolabial angle. Weinberg *et al*.[16] reported retrusion of nasolabial structures in unaffected cleft parents.

Upper and lower lip prominence was normal in most fathers and mothers. An increased percentage of protrusive upper lip was found in fathers, whereas an increased percentage of retrusive upper lip was found in mothers. An increased percentage of protrusive and retrusive lower lips was found in fathers than in mothers. Mamandras *et al*. reported sexual dimorphism with greater dimensions of lips in males.[21] Similar results of the more protrusive upper lip in males were mentioned by Rakhsan and Ghorbanyjavadpour and Ferrario *et al*.[22,23]

On comparing dental inclinations, upper and lower incisors were normally inclined in most parental pairs. Upper and lower incisor proclination was found in greater percentage of fathers and upper incisors were retroclined in greater percentage of mothers. A similar trend of slightly increased inclinations of upper incisors in males was found by Nouri *et al*.[24]

Considering pharyngeal airway dimensions, they were normal in the majority of parents, however, percentage of narrowed upper and lower airways was greater in fathers of CLP patients as compared to mothers.

The clinical importance of studying craniofacial morphology is to identify parental phenotype susceptible to having children with cleft anomalies and investigate trends of the morphology of various dento-craniofacial variables in maternal and paternal groups.

The limitation of this study is that the correlation of type of cleft i.e. unilateral and bilateral with parental craniofacial variables was not studied. Further research to explore the relationship between phenotype and genotype should also be carried out.

CONCLUSION

The craniofacial morphology of most parents of CLP patients was similar to the population norms i.e. class I sagittal skeletal pattern without facial asymmetry and normodivergent vertical pattern. However, there was a trend of relatively increased lower facial height in fathers and decreased lower facial height in mothers. An increased percentage of protrusive upper lips was seen in fathers while an increased percentage of retrusive upper lip was seen in mothers. The airway dimension was normal in the majority of parents with a higher percentage of narrowed upper and lower airways in fathers.

ETHICAL APPROVAL:

Ethical approval was obtained from the Ethical Review Committee of the Armed Forces Institute of Dentistry, Rawalpindi, Pakistan (Letter Ref. No: 918/168 Trg, Dated: 13-05-2020).

PATIENTS' CONSENT:

Patients' consent was obtained prior to acquiring and reproducing diagnostic records and that no identifying information will be disclosed while publishing data.

COMPETING INTEREST:

The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:

EA: Supervision.
RN, EA, AB: Conceptualisation.
QUAT, EA: Data acquisition, analysis, and interpretation.
QUAT, EA, ZA: Writing of the original draft and preparation.
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All authors approved the final version of the manuscript to be published.

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