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Systematic Review on Complications of The Cleft Lip and Palate as Detected by CBCT

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Abstract. Background: Cleft lip and palate are congenital distortions of the upper lip and the roof of the mouth. These cases can cause many problems, like speech problems, feeding problems, and dental abnormalities. Radiographic diagnosis is important for the detection and treatment of these conditions because it allows a detailed evaluation of the anatomical structures.
Aim of the study: To systematically review complications associated with cleft lip and palate as evaluated by CBCT and their inclusion for treatment planning, diagnosis, and long-term treatment.
Material and Methods: This systematic review included studies from 2009 to 2025 that used CBCT to detect complications in people with cleft lip and palate. Databases such as Scopus, Embase, PubMed, and Web of Science were searched with keywords: "radiograph images", "complications", "cleft lip", "cleft palate", and "diagnosis". The articles included were those revealing a clear radiographic presence of complications and their clinical relevance.
Results: The studies reviewed showed that the most commonly detected complications were dental and developmental variations, oropharyngeal narrowing, facial asymmetry, and a reduction in mandibular size. CBCT is a very essential tool for detecting these complications.
Conclusion: CBCT is important for the detection and management of complications related to cleft lip and palate. Radiographs play an important role in early diagnosis and become early interventions for better patient outcomes. The overall care of people with cleft lip and palate needs a multidisciplinary approach including surgeons, radiologists, and speech therapists.

Keywords: Cleft lip and palate, cone beam computed tomography, complication, diagnosis, treatment.

1. Introduction

Cleft lip and cleft palate are the most common congenital craniofacial anomalies that affect the upper lip and the palate. These distortions can cause different aesthetic and functional complications, like speech difficulties, feeding problems, malocclusion, and psychosocial complications. Timely estimations and accurate diagnosis of these complications are important for optimal management and better results[1][2].

Radiograph images have an important role in the diagnosis and treatment of cleft lip and palate. Panoramic radiographs, lateral cephalometric, and cone-beam computed tomography give useful information about skeletal and dental structures, which can assist the surgeon in evaluating anatomical differences and complications. Radiographs are usually useful because they are non-invasive, easily available, and give a detailed evaluation of both hard and soft tissue structures[3][4].

Many studies have revealed that radiograph images of people with cleft lip and palate showed many problems, such as secondary alveolar clefts, delayed tooth development, maxillary hypoplasia, and dental abnormalities like ectopic eruption or agenesis. For interdisciplinary care, including orthodontists, surgeons, and speech therapists, an understanding of these radiographic features is essential[5][6].

The aim of this study is to detect the complications associated with cleft lip and palate as evaluated by CBCT and to provide a thorough summary of their clinical marker, management options, and long-term patient care consequences.

2. Methodology

Study Design

The guidelines for Systematic Reviews and Meta-Analyses (PRISMA) standards were followed in this study. The goal was to detect and collect the studies on the importance of radiographic techniques in the detection of cleft lip and palate.

Inclusion Criteria

Study Types: Original studies that include clinical experiments, retrospective or prospective research, and observational research.

Patients: people with either a cleft palate, cleft lip, or both.

Language: English-language articles.

Time Frame: Studies published between 2009 to 2025

Exclusion Criteria

Conference abstracts, editorials, letters, case reports, and review papers.

Radiographic assessment that has nothing to do with cleft disease or therapy The entire text of the articles is not accessible.

Information Sources and Search Strategy

The following Internet databases were searched thoroughly for relevant literature:

- PubMed
- Scopus
- Web of Science
- Embase

MeSH phrases and keywords were integrated in the search method, including: ("cleft lip" OR "cleft palate" OR "cleft lip and palate") AND ("radiography" OR "radiographic evaluation" OR "imaging" OR "CBCT")

Study Selection

1,456 entries were found in the first search. 1,132 titles and abstracts were evaluated after 324 duplicates were eliminated. A total of 162 full-text papers were evaluated for eligibility. Twenty papers were ultimately included in the qualitative synthesis after meeting the inclusion criteria. Figure 1 shows the PRISMA flow diagram that depicts the selection procedure.

Study Characteristics

• Twenty studies in all satisfied the requirements for inclusion in this systematic review. The studies were published between 2009 and 2025 and were carried out in North America, Europe, Asia, and the Middle East.

• The studies' sample sizes ranged from 10 to more than 100 patients, and they included both unilateral and bilateral CLP instances. While some included adults, the majority concentrated on pediatric and adolescent populations.

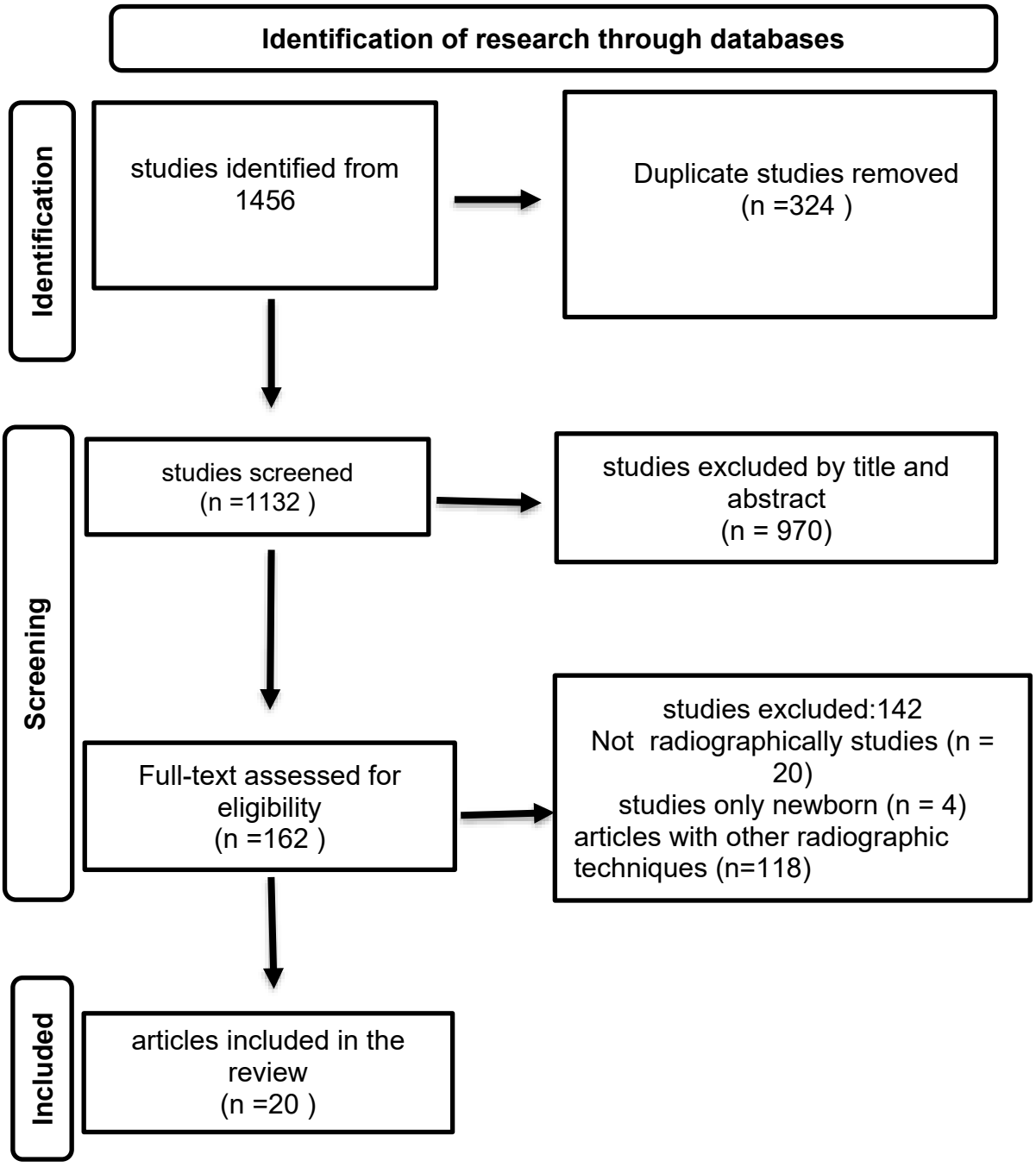

Figure 1. PRISMA flow chart.

3. Result

The most common radiographic technique was CBCT, which was good for its minimal radiation exposure and three-dimensional imaging. Studies including CBCT primarily detect:

1. The shape and the size of the alveolar bone
2. Evaluation of secondary alveolar bone dimensions before and after surgery
3. Impacted teeth and resorption of roots near the cleft region
4. Asymmetry and maxillary dimensions

Craniofacial and Skeletal Morphology

Several articles used 3D CBCT imaging to detect bone morphology and craniofacial asymmetry:

• A morphometric study by Starbuck[7] showed that, in comparison to healthy patients, patients with bilateral cleft lip and palate had significantly different midfacial bone features.

• Significant mandibular and facial asymmetry was shown in unilateral cleft lip and palate patients by Paknahad[8] and Yang[9], who suggested that the cleft influenced both soft and hard tissues.

• Celikoglu[10] revealed that clefting influenced mandible development by finding a reduction in mandibular dimensions in cleft lip and palate patients, particularly in bilateral cases.

• People with surgically treated unilateral clefts revealed continuous soft-tissue asymmetry, suggesting the necessity for outstanding observation[11].

Dental Anomalies and Development

CBCT was used in numerous studies to detect tooth morphology and dental growth in people with clefts:

• Zhou[12] demonstrate that people with clefts had shorter permanent upper incisors, which could have an impact on orthodontic planning.

• Celebi[13] revealed that developmental abnormalities, like root deformities, are usually seen in upper central incisors next to the cleft region.

• In people with unilateral cleft lip and palate, Zhang[14] suggest asymmetrical dental development, which may cause delayed eruption or agenesis in teeth next to the cleft lip and palate.

Bone Grafting and Surgical Outcomes

When evaluating the findings of alveolar bone grafts, CBCT has been important:

• CBCT permits dimensional detection of secondary bone grafts, resulting in persistent defects not obvious in a 2D radiograph image, as shown in the study by Oberoi[15].

• Khalil[16] showed increased precision in detecting bone graft integration by introducing a singular CBCT-based method to measure maxillary variations after grafting.

Airway Assessment

In the treatment of cleft lip and palate, airway clearness and morphology are essential. CBCT was used for 3D airway analysis in a number of studies:

• Patients with CLP, particularly those with bilateral abnormalities, have decreased airway capacity, according to Agarwal, Marwah[17] and Kuang[18].

• Preadolescents with CLP had much smaller oropharyngeal airway spaces, which may raise the risk of obstructive sleep apnea, according to Al-Fahdawi[19].

• These results were corroborated by Celikoglu[20] and Aras[21], who emphasized nasopharyngeal constriction and its effect on breathing.

When employing CBCT for pediatric airway examinations, the DIMITRA Project[22] highlighted the necessity of radiation dosage justification.

Table 1. Summary of included studies.

No.	Reference (Authors, Year)	Study Focus / Topic	Sample/Population	Main Findings / Notes
1	Starbuck et al., 2015	Morphometric analysis of facial skeletal form	Bilateral CLP patients	Significant midfacial skeletal changes in bilateral CLP
2	Celikoglu et al., 2016	Mandibular volume in unilateral & bilateral CLP	Unilateral and bilateral CLP patients	Reduced mandibular volume in CLP, especially bilateral
3	Lee et al., 2013	Volumetric assessment of CLP defects	CLP patients	CBCT effectively measures cleft defect volume
4	Paknahad et al., 2018	Mandibular asymmetry evaluation	CLP patients	Significant mandibular asymmetry in CLP patients
5	Yang et al., 2016	Facial asymmetry in unilateral CLP	Unilateral CLP individuals	Detected facial asymmetry via CBCT
6	Celebi et al., 2015	Effects on permanent upper central incisors	CLP patients	Dental developmental anomalies adjacent to cleft
7	Zhou et al., 2013	Tooth lengths of permanent upper incisors	CLP patients	Shorter upper incisors in CLP detected with CBCT
8	Zhang et al., 2016	Asymmetric dental development in unilateral cleft lip	Unilateral cleft lip and alveolus patients	Asymmetrical dental development identified
9	Starbuck et al., 2014	Facial soft-tissue asymmetry post-surgery	Surgically corrected unilateral cleft children	Persistent soft tissue asymmetry after repair
10	Oberoi et al., 2009	Volumetric assessment of secondary alveolar bone graft	CLP patients with bone grafting	CBCT valuable for graft volume assessment
11	Agarwal & Marwah, 2016	Airway characteristics in children with CLP	Pediatric CLP patients	Reduced airway dimensions detected via CBCT
12	Al-Fahdawi et al., 2018	Oropharyngeal airway analysis in bilateral/unilateral CLP	Preadolescent non-syndromic CLP patients	Significant oropharyngeal narrowing reported
13	Kuang et al., 2021	Pharyngeal airway volume and craniofacial morphology	Bilateral CLP patients	Reduced airway volume and altered morphology
14	Aras et al., 2012	Nasopharyngeal airway evaluation (3D vs 2D methods)	Unilateral CLP patients	3D CBCT more accurate than 2D methods
15	Celikoglu et al., 2014	Pharyngeal airway volume in adolescent bilateral CLP	Adolescents with bilateral CLP	Confirmed airway volume reduction
16	DIMITRA Project, 2017	CBCT use in pediatric dentistry & volumetric assessment	Pediatric unilateral CLP patients	Guidelines emphasizing radiation dose optimization
17	Khalil et al., 2025	Maxillary changes post secondary alveolar bone grafting	Unilateral CLP patients	Novel CBCT quantification approach introduced
18	MDPI , 2024	Mandibular osseous	CLP patients	Reduced bone complexity

No.	Reference (Authors, Year)	Study Focus / Topic	Sample/Population	Main Findings / Notes
		architecture assessment via fractal		in mandibular structure
19	MDPI , 2022	Incidental findings in CLP patients	CLP patients and controls	High incidence of incidental radiographic findings
20	SciELO , 2020	Maxillary expansion evaluation in twins with CLP	Twins with CLP	CBCT effective for monitoring maxillary expansion

4. Discussion

This systematic review synthesizes findings from 20 studies evaluating the utility of Cone Beam Computed Tomography (CBCT) in the radiographic assessment of patients with cleft lip and/or palate (CLP). The combined results highlight the fundamental advantage of CBCT in providing a 3D, high-resolution image of skeletal structures, permitting more accurate diagnosis, treatment planning, and post-surgical assessment in these complicated cases,

- Craniofacial and Skeletal Morphology

• The included research consistently revealed that craniofacial bone morphology significantly varies in patients with cleft lip and palate. Both unilateral and bilateral cleft cases revealed notable midfacial and mandibular dimensions variations, according to the studies by Starbuck and Celikoglu. Paknahad and Yang, who used CBCT to detect minute differences that might not be observed with conventional 2D imaging, further enhance asymmetry, particularly in the mandible and maxilla.

- These findings have significant clinical implications. Planning for orthognathic surgery and orthodontic treatment depends on accurate craniofacial asymmetry evaluation. Also, Starbuck. showed that soft-tissue asymmetry continues following surgical correction, suggesting the significance of thorough 3-dimensional detection in follow-up care.
- **Dental Anomalies and Developmental Variations**

• People with cleft lip and palate had a high frequency of dental distortion, according to CBCT imaging. Shortened and distorted upper central incisors, especially at the cleft area, were demonstrated by Zhou and Celebi. These distortions make grafting, prosthesis planning, and orthodontic alignment more difficult.

• Zhang showed that asymmetric dental development in people with unilateral clefts may cause eruption patterns to vary or be delayed. These findings prove the usefulness of CBCT in the early detection and treatment of dental distortion, providing accurate measures that can influence the type and timing of treatment.

- **Evaluation of Alveolar Bone Grafting**

• The evaluation of secondary alveolar bone grafts is one of the most essential advantages of CBCT. Oberoi suggest that CBCT could correctly measure transplant dimensions and detect postoperative residual defect. A new method for detecting maxillary bone changes over time was recently demonstrated by Khalil, giving a possible benchmark for postoperative graft assessment.

• These articles highlight how dimensional evaluation using CBCT confirms surgical outcome detection objectivity, which may increase graft success value and decrease the need for change surgeries.

- **Airway Assessment**

• Several studies found that people with cleft lip and palate had compromised airway dimensions, including those by the studies of Agarwal, Marwah, Kuang, Al-Fahdawi. Significant oropharyngeal constriction was usually shown in bilateral cleft patients, increasing concerns regarding breathing defects during sleep and other functional deficits.

• Comprehensive airway dimension is made correctly by CBCT, which is important for planning procedures such as orthognathic surgery or maxillary expansion. The findings further showed that the multidisciplinary treatment of people with cleft lip and palate should include routine airway examination.

• It is essential to remember that dynamic airway assessment, such as sleep research, cannot be completely replaced by calm CBCT imaging. A more overall understanding of airway defects in this study may be possible with additional CBCT incorporation with functional assessment.

- **Incidental Findings and Structural Analysis**

• According to the results of the MDPI study in[23], incidental diseases like sinus abnormalities and impacted teeth are usually shown by CBCT images. Even though imaging may not be the main assurance of these results, their detection can result in early intervention and better patient outcomes.

• Cutting-edge methods like fractal analysis show as tools to detect bone quality, which could confirm the evaluation of bony defects in cleft lip patients.

- **Radiation Exposure and Ethical Considerations**

• The use of CBCT, particularly in pediatric patients, needs to be justified in spite of its diagnostic advantages. The ALARA principle is one of the radiation safety guidelines that must be followed, according to the DIMITRA study. The usual use of CBCT must be justified against clinical necessity, especially in follow-ups when several images are usually required, even though it gives lower exposure doses than standard CT.

5. Conclusion

The advantage of CBCT in the thorough evaluation of people with cleft lip and palate is shown by this systematic review. When compared to conventional 2-dimensional imaging techniques, CBCT showed greater accuracy in detecting maxillofacial morphology, dental abnormalities, alveolar bone dimensions, and airway defects across the analyzed investigations. Accurate diagnosis and treatment planning are made possible by using CBCT, particularly when it comes to measuring post-surgical variations, detecting dental development, and evaluating skeletal asymmetries. Its 3-dimensional capabilities facilitate a multidisciplinary approach to cleft treatment and enhance clinical decision-making. However, radiation exposure needs to be taken into account, especially for children. The guidelines of justification and optimization should usually guide the use of CBCT, noting a balance between patient safety and diagnostic interest. CBCT is considered an essential technique for the radiological treatment of cleft lip and palate and needs to be integrated into standard clinical procedures when suitable. To further improve patient results, future studies should focus on standardizing imaging techniques, decreasing radiation exposure, and integrating CBCT with functional assessment.

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