Holistic Clinical Stewardship in Cleft Lip and Palate Care: An Interdisciplinary Approach

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Abstract: Cleft lip and palate (CL/P) represent the most prevalent congenital craniofacial anomalies and pose significant functional, esthetic, and psychosocial challenges throughout an individual's life. These conditions commonly present with facial deformity, impaired speech and hearing, malocclusion, missing or malformed teeth, and oronasal communication, requiring complex and long-term clinical management. The concept of holistic clinical stewardship emphasizes coordinated, patient-centered care delivered through an interdisciplinary framework that integrates medical, surgical, and dental specialties across different stages of growth and development. This article aims to highlight the importance of holistic and interdisciplinary care in the management of cleft lip and palate by reviewing contemporary clinical protocols followed globally. The role of collaborative treatment planning involving plastic and maxillofacial surgery, orthodontics, pediatric and restorative dentistry, prosthodontics, Periodontist, otolaryngology, speech therapy, psychology, and social services is discussed. Emphasis is placed on the benefits of structured team coordination in reducing treatment fragmentation, improving functional outcomes, and enhancing esthetic rehabilitation. The paper further underscores the need for standardized clinical pathways to ensure continuity of care from infancy to adulthood and to optimize overall quality of life for individuals affected by cleft anomalies.

Keywords: Cleft lip and palate; Interdisciplinary care; Multidisciplinary management; Holistic clinical stewardship; Craniofacial anomalies; Dental rehabilitation; Team-based treatment; Quality of life

Introduction

Cleft lip and palate (CLP) are among the most prevalent congenital craniofacial anomalies, arising from disruption in the fusion of facial processes during early embryogenesis. These anomalies result in a wide spectrum of structural deformities involving the lip, alveolus, palate, nose, and maxillofacial skeleton. Beyond facial disfigurement, CLP significantly affects essential functions such as feeding, speech, hearing, mastication, breathing, and psychosocial development, thereby exerting a profound impact on overall quality of life[1].

The complexity of CLP lies in its multifactorial etiology and its influence on multiple anatomical systems. Dental abnormalities such as missing or malformed teeth, maxillary deficiency, malocclusion, periodontal compromise, and altered facial growth patterns are common findings. Additionally, individuals often experience social stigma, communication difficulties, and emotional distress, especially during childhood and adolescence[1 2].

Given these multifaceted challenges, isolated or single-specialty management is inadequate. Instead, successful treatment demands a holistic, patient-centered, and interdisciplinary approach involving close collaboration among medical and dental professionals. The objective of interdisciplinary cleft care is not only to correct anatomical defects but also to restore function, esthetics, periodontal health, and psychosocial well-being throughout the patient's growth and development[2 3].

Embryology of Cleft Formation

Cleft lip and palate (CLP) arise due to disturbances in the intricate embryological development of the face and palate. Understanding the timing and sequence of facial morphogenesis is essential for comprehending the origins of these anomalies and their clinical implications.

Early Facial Development: Weeks 5–7

Facial morphogenesis begins during the **fifth week of gestation**, a critical period when multiple facial processes converge to form the upper lip, nose, and primary palate[3]. By the **sixth week**, the medial nasal processes and the maxillary processes normally fuse to form a continuous upper lip and the primary palate. Failure or disruption of this fusion results in **cleft lip**, which may be unilateral or bilateral, depending on the affected processes[3 4]

The development of these structures is highly coordinated and depends on cellular proliferation, migration, and apoptosis. Any interruption in these cellular events—whether due to genetic mutations, teratogenic exposures, or mechanical interference—can impair fusion and lead to cleft formation[5].

Formation of the Secondary Palate: Weeks 7–12

The **secondary palate** develops slightly later, beginning around the **seventh week** and completing fusion by the **twelfth week** of gestation[6]. Bilateral palatal shelves, which arise from the maxillary processes, initially grow vertically on either side of the tongue. These shelves subsequently **elevate, rotate horizontally, and fuse at the midline** to form the intact secondary palate.

Disruptions during this process can result in a **cleft palate**, either isolated or in combination with cleft lip. Factors contributing to incomplete palatal fusion include abnormal tongue posture, mechanical obstruction, and delayed shelf elevation[6 7].

Etiological Factors Affecting Fusion[6 7 8]

Several intrinsic and extrinsic factors can interfere with normal facial development:

- **Genetic mutations**: Variants in key developmental genes may alter signaling pathways essential for tissue growth and fusion.
- **Teratogenic exposures**: Maternal smoking, alcohol intake, certain medications, or infections during pregnancy can impair normal morphogenesis.
- **Mechanical influences**: Abnormal positioning of the tongue or intrauterine constraints may physically prevent proper fusion of the palatal shelves[3].

The interplay between these genetic and environmental factors explains the **multi factorial etiology** of nonsyndromic cleft lip and palate, emphasizing the complexity of facial development and the need for timely clinical interventions[13–15].

Clinical Implications of Embryological Disruptions

Understanding embryology provides insight into the **location and severity** of clefts. For example, clefts affecting the primary palate often involve the alveolus and lip, while secondary palate clefts impact speech and feeding function. Early knowledge of the embryological origin aids in planning **surgical repair, orthodontic management, and prosthetic rehabilitation**, ensuring better functional and esthetic outcomes[12–7]

Etiology of Cleft Lip and Palate

The etiology of cleft lip and palate (CLP) is complex and multi factorial, resulting from interplay between genetic predisposition and environmental influences acting during early embryonic development. Genetic factors play a significant role and include chromosomal abnormalities, single-gene mutations, and familial inheritance patterns[11 12]. CLP may occur as part of well-recognized syndromes such as Van der Woude syndrome, Pierre Robin sequence, and Stickler syndrome, or as isolated nonsyndromic conditions. Individuals with a positive family history of clef ting exhibit a higher risk of recurrence, indicating a strong hereditary component.

Environmental factors further contribute to the development of CLP by disrupting normal facial morphogenesis[12,17]. Maternal exposure to tobacco smoke, alcohol consumption, nutritional deficiencies (particularly folic acid), viral infections, radiation, psychological stress, and the use of certain teratogenic medications during pregnancy have been strongly associated with increased risk. Additionally, maternal systemic conditions such as diabetes and obesity may influence embryonic craniofacial development.

Most nonsyndromic cases arise from polygenic inheritance combined with environmental insults occurring during the critical period of facial formation, typically between the fifth and twelfth weeks of gestation. Understanding these etiological mechanisms is essential for risk assessment, genetic counseling, and the development of preventive strategies.

Clinical Problems Associated With Cleft Lip and Palate

Cleft lip and palate (CLP) present with a wide range of clinical problems that extend beyond visible facial deformity. These challenges affect structural integrity, physiological function, oral health, communication ability, and psychosocial well-being. The severity and combination of these problems vary depending on the type and extent of the cleft, associated syndromes, and timing of intervention. Understanding these clinical manifestations is essential for formulating a comprehensive and effective multidisciplinary treatment plan[18 20].

1. Structural and Functional Problems

Facial Asymmetry and Nasal Deformity

Facial asymmetry is one of the most prominent features in individuals with CLP. Disruption of normal facial growth results in deviation of the nasal septum, flattening of the nasal alar cartilage, and distortion of the lip and columella. These deformities not only compromise facial esthetics but also affect nasal airflow and breathing. Scar tissue following surgical repair may further restrict facial growth and exacerbate asymmetry[21].

Malocclusion and Maxillary Hypoplasia

Maxillary growth deficiency is commonly observed in CLP patients due to intrinsic developmental defects and surgical scarring[22]. This often leads to Class III skeletal relationships, anterior crossbite, transverse maxillary constriction, and facial profile disharmony. Malocclusion affects mastication, speech articulation, and temporomandibular joint function, requiring long-term orthodontic and surgical intervention.

Missing, Malformed, or Impacted Teeth

Dental anomalies are highly prevalent in cleft patients, particularly in the region of the cleft. Congenital absence of lateral incisors is most common, followed by malformed or supernumerary teeth. Tooth impaction and ectopic eruption frequently occur due to insufficient alveolar bone and space deficiency[23]. These conditions complicate orthodontic treatment and often necessitate prosthodontic rehabilitation.

Oronasal Fistula

Residual oronasal fistulae may persist following palatal repair or develop due to wound dehiscence. These fistulae allow communication between the oral and nasal cavities, leading to nasal regurgitation of food, impaired speech, and increased risk of infection. Surgical closure or prosthetic obturation is often required[24].

Speech and Resonance Disorders

Speech impairment is one of the most significant functional consequences of CLP. Inadequate velopharyngeal closure results in hypernasality, nasal air emission, articulation errors, and compensatory speech patterns. Without early intervention, these abnormalities may become permanent. Speech therapy combined with surgical or prosthetic correction plays a crucial role in rehabilitation.

Hearing Impairment and Middle Ear Disease

Eustachian tube dysfunction is common in CLP due to abnormal palatal muscle attachment, leading to recurrent otitis media and conductive hearing loss. Persistent hearing deficits can negatively affect language acquisition and academic performance. Regular audio logical monitoring and tympanostomy tube placement are often necessary.

Airway Compromise

Structural abnormalities of the nasal cavity, maxilla, and pharynx can result in airway obstruction, mouth breathing, snoring, and sleep-disordered breathing. In severe cases, obstructive sleep apnea may develop, further impairing growth, cognition, and overall health.

2. Oral and Periodontal Problems

Oral health in CLP patients is frequently compromised due to altered anatomy, orthodontic appliances, and limited access for oral hygiene.

Increased Caries Risk

Enamel hypoplasia, crowding, and prolonged use of feeding appliances increase susceptibility to dental caries. Poor oral hygiene practices further exacerbate the risk.

Periodontal Complications

Periodontal problems are especially prevalent near the cleft region. Abnormal gingival architecture, scar tissue, and orthodontic forces contribute to plaque accumulation, gingivitis, periodontal pocketing, and attachment loss[22,23]. Bone defects in the alveolar cleft area increase the risk of localized periodontal breakdown and tooth mobility.

Peri-implant Challenges

In patients receiving dental implants, compromised bone quality and soft tissue support may increase the risk of peri-implantitis. Meticulous periodontal maintenance is therefore essential for long-term implant success.

3. Psychosocial and Emotional Problems

Psychosocial difficulties constitute a major but often underestimated dimension of CLP.

Psychological Impact in Childhood

Children with CLP may experience teasing, bullying, and social exclusion due to facial differences and speech problems. These experiences often result in low self-esteem, anxiety, emotional withdrawal, and impaired academic performance.

Challenges in Adolescence and Adulthood

During adolescence, concerns regarding appearance and social acceptance become more pronounced. Adults may face difficulties in forming interpersonal relationships, pursuing employment opportunities, and participating confidently in social settings. Persistent dissatisfaction with facial appearance may lead to depression and reduced quality of life.

Family and Caregiver Burden

Parents and caregivers often experience emotional stress, financial strain, and social challenges while navigating long-term treatment. Family-centered psychological support is therefore an integral component of cleft care

Multidisciplinary Management and Treatment Protocol in Cleft Lip and Palate

Multidisciplinary Team Approach

The successful management of cleft lip and palate (CLP) is fundamentally dependent on the **synergistic collaboration of multiple medical and dental specialties** working within a structured and coordinated framework. Given the complex anatomical, functional, and psychosocial implications of cleft anomalies, no single discipline can independently achieve comprehensive rehabilitation. Instead, an **integrated multidisciplinary model** ensures seamless continuity of care from infancy to adulthood, enabling timely interventions, minimizing treatment burden, and maximizing long-term functional and esthetic outcomes[24].

This collaborative strategy promotes **collective clinical decision-making**, where treatment planning is guided by shared goals rather than isolated procedures. Regular team meetings, coordinated follow-up schedules, and patient-centered planning allow for adaptive care that evolves with growth and individual needs[25].

Plastic and Reconstructive Surgeon

The plastic and reconstructive surgeon occupies a pivotal role during the early stages of cleft management. Primary lip repair usually performed between 10 and 12 weeks of age, aims to re-establish muscular continuity, improve facial symmetry, and enhance parental bonding. Palatal repair is typically completed between 9 and 12 months, facilitating normal speech acquisition and feeding patterns.

In later developmental phases, the surgeon performs secondary procedures such as lip revision, nasal reconstruction, velopharyngeal correction, and definitive rhinoplasty. These interventions refine facial harmony, improve airway function, and address residual esthetic concerns[26].

Oral and Maxillofacial Surgeon

The oral and maxillofacial surgeon plays a decisive role in the **skeletal rehabilitation** of CLP patients. Alveolar bone grafting restores maxillary continuity, supports eruption of permanent teeth, and provides a foundation for future implant placement. In cases of severe maxillofacial discrepancy, **orthognathic surgery** corrects skeletal mal relationships and improves facial proportions, occlusion, and airway patency[27].

Advanced techniques such as **distraction osteogenesis** may be employed to stimulate bone formation and enhance midfacial growth, particularly in patients with significant maxillary deficiency.

Orthodontist

Orthodontic care represents the **central axis of long-term cleft management**, spanning multiple growth phases. In infancy, presurgical nasoalveolar molding (NAM) reduces cleft severity and improves nasal architecture prior to surgical repair. During mixed dentition, orthodontic expansion and alignment optimize arch form and prepare the alveolar cleft site for bone grafting.

Comprehensive orthodontic treatment in adolescence establishes functional occlusion, improves facial balance, and prepares patients for orthognathic surgery or prosthodontic rehabilitation. The orthodontist thus ensures both biological stability and esthetic harmony.

Periodontist

The periodontist plays a **crucial biological stewardship role** in maintaining periodontal integrity throughout treatment. Abnormal gingival anatomy, scar tissue, orthodontic forces, and compromised oral hygiene predispose cleft patients to periodontal disease, particularly near the cleft region.

Periodontists manage gingival inflammation, perform soft tissue grafting, enhance keratinized tissue, and correct mucogingival defects. They also prepare peri-implant tissues, support orthodontic movement, and ensure long-term periodontal stability, which is essential for the success of prosthetic and implant-based rehabilitation.

Pediatric Dentist

Pediatric dentists are responsible for **early preventive and restorative care**, beginning in infancy. Their role includes caries risk assessment, fluoride therapy, sealant application, dietary counseling, and maintenance of primary dentition. Behavioral management techniques help alleviate dental anxiety and foster lifelong oral health habits.

Early interceptive orthodontic measures may also be implemented to guide eruption patterns and reduce the severity of future malocclusion.

Prosthodontist

Prosthodontic intervention focuses on the **functional and esthetic restoration** of missing or malformed oral structures. Obturators are used to close residual palatal defects and improve speech resonance. Fixed, removable, and implant-supported prostheses restore masticatory efficiency, facial support, and self-confidence.

The prosthodontist plays a vital role in the final stages of rehabilitation, transforming surgical and orthodontic achievements into practical, patient-centered outcomes.

Speech-Language Pathologist

Speech-language pathologists address one of the most impactful consequences of CLP—**communication impairment**. They assess articulation, resonance, and language development, initiating therapy early to prevent compensatory speech patterns.

Management of velopharyngeal dysfunction often requires close coordination with surgeons and prosthodontists. Feeding and swallowing therapy during infancy further supports safe nutrition and growth.

Otolaryngologist and Audiologist

ENT specialists manage **hearing, airway, and nasal function**, which are frequently compromised in CLP patients. Recurrent otitis media, Eustachian tube dysfunction, and nasal obstruction are common and may lead to long-term hearing loss if untreated.

Audiologists conduct routine hearing assessments and provide rehabilitative support such as hearing aids, ensuring optimal auditory input for speech and cognitive development.

Pediatrician and Geneticist

Pediatricians monitor systemic health, nutritional status, immunization schedules, and developmental milestones. Geneticists identify syndromic conditions, counsel families regarding recurrence risk, and contribute to preventive health strategies. Their involvement ensures that cleft care is aligned with overall medical well-being.

Psychologist and Social Worker

Psychological and social dimensions are integral to holistic cleft management. Patients often experience emotional distress, social stigma, and reduced self-esteem. Psychologists provide counseling to enhance coping mechanisms, emotional resilience, and body image.

Social workers facilitate access to healthcare services, financial assistance, and community resources, reducing barriers to long-term treatment compliance.

The Power of Collaboration

Ultimately, the multidisciplinary team functions as a **single cohesive clinical entity**, where each specialist contributes unique expertise toward a shared objective: restoring function, appearance, confidence, and social integration. This collaborative stewardship not only improves clinical outcomes but also transforms the patient's life trajectory through compassionate, comprehensive, and coordinated care.

Comprehensive Treatment Protocol

The management of cleft lip and palate (CLP) is not a single event but a **dynamic, lifelong therapeutic journey** that evolves in harmony with the patient's growth, functional demands, and psychosocial development. Effective cleft care requires a **strategically phased treatment protocol**, where each intervention is precisely timed to maximize biological potential and minimize long-term complications. This longitudinal approach ensures that anatomical correction is complemented by functional rehabilitation and emotional well-being[27, 28].

Neonatal Period (0–1 Year): Establishing the Foundation

The neonatal phase represents the **cornerstone of cleft management**, with emphasis on survival, nutrition, and parental support. Feeding difficulties are among the earliest challenges, often resulting from oronasal communication and poor suction. Specialized

feeding bottles, obturators, and positioning techniques play a vital role in preventing nasal regurgitation, aspiration, and failure to thrive.

Pre-surgical orthopedic interventions such as **nasoalveolar molding (NAM)** are initiated during this stage to approximate alveolar segments, reduce cleft width, and improve nasal cartilage symmetry. These measures significantly enhance surgical outcomes and reduce the extent of later reconstructive procedures.

Primary **lip repair is typically performed around 3 months of age**, restoring facial continuity and muscular balance, followed by **palatal repair between 9 and 12 months**, which is crucial for normal speech development and feeding efficiency.

Early Childhood (1–7 Years): Functional Rehabilitation

Early childhood is a **critical period for speech, hearing, and psychosocial development**. Following palatal closure, **speech therapy becomes a central component** of care, aiming to prevent compensatory articulation patterns and hypernasality. Early intervention during this stage greatly improves long-term communication outcomes.

Pediatric dental care focuses on preventive strategies, including fluoride application, sealants, dietary counseling, and maintenance of primary dentition. Regular **ENT monitoring** is essential for early detection of otitis media and hearing impairment, which are highly prevalent due to Eustachian tube dysfunction.

Psychological support during this phase fosters self-esteem, social integration, and emotional resilience, particularly as children begin school and social interactions intensify[28, 29].

Mixed Dentition Phase (6–12 Years): Structural Optimization

The mixed dentition stage represents a **pivotal turning point in cleft rehabilitation**, as skeletal growth becomes more evident. One of the most important interventions during this phase is **alveolar bone grafting**, usually performed between 8 and 10 years, to restore continuity of the maxillary arch, facilitate eruption of permanent teeth, and provide support for future prosthetic or implant therapy.

Orthodontic expansion is often required to correct transverse maxillary constriction and establish proper arch form. Simultaneously, **periodontal therapy plays a crucial role** in preserving gingival health around the cleft region, where scar tissue, abnormal anatomy, and orthodontic forces increase the risk of attachment loss and inflammation.

Adolescence and Adulthood: Definitive Rehabilitation

Adolescence marks the transition from growth modification to **definitive functional and esthetic correction**. Comprehensive fixed orthodontic treatment aligns dentition,

establishes stable occlusion, and prepares patients for **orthognathic surgery** when significant skeletal discrepancies persist.

Prosthodontic rehabilitation addresses missing or malformed teeth using fixed, removable, or implant-supported prostheses, thereby restoring masticatory efficiency and facial harmony. Final procedures such as **rhinoplasty, lip revision, and scar refinement** complete the treatment process, significantly enhancing facial appearance and patient confidence[30].

A Lifelong Perspective

Importantly, cleft care does not conclude with surgical completion. **Lifelong follow-up** is essential to monitor periodontal health, speech quality, airway function, psychological well-being, and prosthetic maintenance. The ultimate goal of this comprehensive protocol is not merely anatomical closure, but the **restoration of function, self-image, social participation, and overall quality of life**

Discussion

The management of cleft lip and palate (CLP) has undergone a significant transformation over recent decades. Earlier treatment models were predominantly surgical, with primary emphasis on anatomical closure of defects during infancy. While early surgical repair improved survival and basic esthetics, long-term outcomes were often compromised due to inadequate functional rehabilitation and lack of interdisciplinary coordination, as described by **Moore**, **Malcolm and Johnston**, and **Persaud et al.** Marcusson and Mars et al. further reported that isolated surgical protocols frequently resulted in residual speech defects, maxillary hypoplasia, dental anomalies, and psychosocial limitations in adulthood.

Contemporary cleft care has shifted toward a comprehensive, patient-centered, interdisciplinary paradigm. This approach integrates surgical, orthodontic, periodontal, prosthetic, and speech interventions to achieve functional harmony and psychosocial reintegration, as emphasized by **Berkowitz**, **Evans**, and **Abu-Hussein**. Advances in imaging technologies, particularly cone-beam computed tomography and three-dimensional facial analysis, have enhanced diagnostic accuracy and treatment planning, enabling precise evaluation of skeletal relationships and alveolar defects, as demonstrated by **Trotman et al.** and **Murray**. Similarly, innovations in surgical techniques such as nasoalveolar molding, tissue grafting, and distraction osteogenesis have significantly improved facial symmetry, occlusal stability, and airway dimensions, as reported by **Black and Scheflan**, **Waite and Waite**, and **Tindlund**.

Despite these technological advancements, fragmented care remains a major contributor to suboptimal outcomes. Poor coordination between surgeons and orthodontists may

lead to arch collapse, maxillary retrusion, and increased relapse rates, as observed by **Vlachos** and **Shetye**. Inadequate periodontal support further compromises orthodontic movement, implant integration, and prosthetic longevity, which has been clearly documented by **Reisberg** and **Abu-Hussein**. These findings reinforce the necessity of periodontal involvement as a biological foundation for long-term treatment stability.

The interdisciplinary model addresses these limitations by promoting sequential and collaborative intervention. Early pediatric dental care and speech therapy enhance oral hygiene and communication development, while orthodontic supervision facilitates successful alveolar bone grafting and skeletal correction, as supported by **Hotz and Gnoinski** and **David et al.** Prosthodontic rehabilitation restores esthetics and function, and psychological support improves emotional resilience and social adaptation, as highlighted by **Sapp et al.** and **Kesave et al.**

Cleft lip and palate should therefore be viewed as a dynamic condition requiring lifelong monitoring. Growth-related changes in craniofacial structures demand adaptive strategies from childhood through adulthood, as demonstrated by **Meazzini et al.** and **Fudalej et al.** Evidence consistently shows that patients treated under coordinated multidisciplinary care exhibit superior facial esthetics, improved speech intelligibility, better occlusal outcomes, and higher quality-of-life scores compared to those managed using isolated approaches, as reported by **Kharbanda et al.** and **Rohrich et al.**

In summary, modern CLP management extends beyond anatomical repair to encompass functional rehabilitation and psychosocial restoration. The success of treatment lies in interdisciplinary clinical stewardship, precise timing of interventions, and holistic patient-centered care, ultimately transforming cleft lip and palate into a manageable lifelong condition with excellent biological, functional, and social outcomes.

Conclusion

Cleft lip and palate represent complex congenital anomalies requiring sustained interdisciplinary collaboration. The holistic integration of surgeons, orthodontists, periodontists, pediatric dentists, prosthodontists, speech therapists, psychologists, and social workers is essential for achieving optimal outcomes. Interdisciplinary clinical stewardship ensures restoration of function, esthetics, periodontal health, and psychosocial well-being, ultimately transforming lives through comprehensive care.

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