BMC Oral Health

CASE REPORT Open Access

Successful interdisciplinary retreatment after initial treatment failure in a cleft lip adolescent

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Abstract

Background Cleft lip and/or palate (CL/P) is the most common craniofacial birth defect. Patients with CL/P typically exhibit severe malocclusions in the transverse, vertical, and sagittal directions, and often have poor oral hygiene. Due to the complex nature of the disease, the dental treatment for CL/P patients presents considerable challenges, sometimes resulting in interrupted treatments and subsequent treatment failures.

Case presentation Here, we present an interdisciplinary retreatment for an adolescent with unilateral complete cleft lip (UCCL), who initially received an orthodontic treatment elsewhere but faced issues such as poor oral hygiene, deep overbite of anterior teeth, significant discrepancies in the width of posterior teeth, and persistent spaces resulting from the alveolar cleft. Throughout the retreatment, we employed tooth remineralization accompanied by strict oral hygiene instructions, various skilled orthodontic techniques, surgical interventions, and aesthetic prosthodontic work. The adolescent showed dramatic improvements in facial and dental aesthetics, as well as in dental occlusion and function after treatment.

Conclusions In summary, this case report emphasizes the critical role of effective oral hygiene management and interdisciplinary teamwork among dental subspecialties in the treatment of CL/P patients.

Keywords Cleft lip and/or palate, Oral hygiene, Interdisciplinary retreatment, Orthodontics, Case report

Background

Cleft lip and/or palate (CL/P) is the most prevalent craniofacial congenital anomaly, affecting approximately 1.416 per 1,000 live births worldwide [1]. This defect, characterized by the unsuccessful fusion of the lip, palate, and alveolar bone, leads to notable aesthetic concerns and functional challenges in eating and speaking [2]. Consequently, CL/P affects not only the physical health of children but also significantly influences their psychological well-being and social interactions [3, 4].

Currently, the management of CL/P involves a multidisciplinary approach that includes presurgical nasoalveolar molding, surgical repair of the cleft lip and palate, speech therapy, psychotherapy, alveolar bone grafting, orthodontic interventions, rhinoplasty, and orthognathic surgery, etc [5–8]. Within the treatment framework,

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dental interventions are essential in the comprehensive management of CL/P [9].

However, due to the complex nature of CL/P, the dental treatment for patients with this anomaly presents considerable challenges. The alveolar cleft typically disrupts the continuity of the dental arch and hinders tooth eruption [10]. Furthermore, previous studies have indicated that patients with CL/P are at an increased risk of tooth demineralization and caries compared to those without CL/P [11]. In addition, discrepancies in the dimensions of length, width, and height further complicate achieving satisfactory dental treatment outcomes for CL/P patients [12]. All of these factors can sometimes lead to interrupted treatments and subsequent treatment failures.

This case report presents a successful interdisciplinary retreatment of an adolescent with unilateral complete cleft lip (UCCL), who experienced an unsuccessful outcome from the initial dental treatment.

Case presentation

Medical history, symptoms, and diagnosis

A 16-year-old male adolescent visited the Hospital of Stomatology, Xi'an Jiaotong University, with the chief complaint to continue his orthodontic treatment and address severe tooth surface demineralization. Diagnosed with a unilateral complete cleft lip on the right side at birth, he underwent cleft lip repair and received speech therapy in his infancy and early childhood. The patient has no relevant family history. At the age of nine, the patient underwent alveolar bone grafting surgery. Approximately two years prior to this visit, he began orthodontic treatment for permanent teeth at another dental clinic. However, the treatment was halted due to persistent spaces in the upper arch, severely misaligned occlusion, and extensive tooth demineralization/caries, which the previous dentist was unable to manage.

The patient exhibited a scar extending from the right upper lip to the base of the nose, resulting in asymmetrical peaks of the upper lip. Additionally, nasal asymmetry was evident, with a collapsed right nostril. His facial profile revealed protrusion of both the upper and lower lips (Fig. 1a). Fixed orthodontic appliances were bonded to the surfaces of teeth, accompanied by a removable occlusal splint for the maxillary posterior teeth. Moreover, the adolescent's oral hygiene was notably poor, characterized by significant accumulation of calculus and plaque around the brackets, even on the front teeth (Fig. 1b). Upon examination with a dental probe, the surrounding areas of the brackets felt soft. After the occlusal splint was removed, the patient presented bilateral Class II relationships for both canines and molars, with an overjet of 4 mm and a pronounced deep overbite (Fig. 1c). A fissure was observed in the gingiva distal to the right upper central incisor, corresponding to the location of the alveolar cleft (Fig. 1b). The right upper lateral incisor displayed microdontia, accompanied by a 6 mm space mesial to this tooth (Fig. 1b). The bilateral mandibular posterior teeth were lingually inclined, resulting in a scissor bite of the right premolars and first molars, while the left premolars and molars showed a significant deep overjet (Fig. 1b **and c**).

The pretreatment lateral cephalometric assessment revealed a skeletal Class I relationship (ANB = 2.2°) and a low mandibular plane (GoGn-SN = 21.9°). The maxillary incisors were slightly forward-leaning (U1-NA = 7.7 mm), whereas the mandibular incisors were slightly lingually inclined (L1-NB = 3.1 mm) (Fig. 2a **and** Table 1). The pretreatment panoramic radiograph showed three impacted third molars and a shortened root for the right upper lateral incisor (Fig. 2b). In addition, the pretreatment CBCT indicated the presence of bone at the site of the alveolar cleft bone graft (Fig. 2c), along with a considerable amount of bone on the buccal sides of the bilateral mandibular molars, which were lingually inclined (Fig. 2d).

Based on the medical history and examinations, the diagnosis for the adolescent included UCCL, a bone-grafted alveolar cleft, and enamel demineralization resulting from orthodontic treatment.

Treatment objectives and strategy

The treatment objectives were to: (1) improve the patient's oral hygiene and address the demineralization of enamel, (2) establish an ideal functional occlusion for both anterior and posterior teeth, and (3) achieve dental and facial aesthetics.

The treatment strategy included: (1) removal of the existing fixed appliances, remineralization of the teeth, and providing instructions for oral hygiene, (2) aligning the upper teeth and reducing the overbite with a flat anterior bite plate, (3) uprighting the lower molars that lingually inclined, (4) closure of the space in the upper arch and preservation of space for the prosthetic management of the microdontia, (5) surgical interventions to enhance nasolabial esthetics, and (6) use of a Hawley retainer equipped with a flat anterior bite plate to ensure the long-term stability of the treatment outcomes.

Treatment methodology and progress

Initially, we removed all orthodontic appliances and conducted supragingival scaling, followed by the remineralization treatment for this adolescent. For remineralization therapy, a fluoride varnish containing 5% sodium fluoride was utilized (3M™ Clinpro™ White Varnish). Fluoride varnish application was performed after thorough plaque removal and complete drying of the tooth surfaces. A thin layer of varnish was evenly applied using a small brush. The treatment was repeated after four weeks, and the patient was instructed to follow up

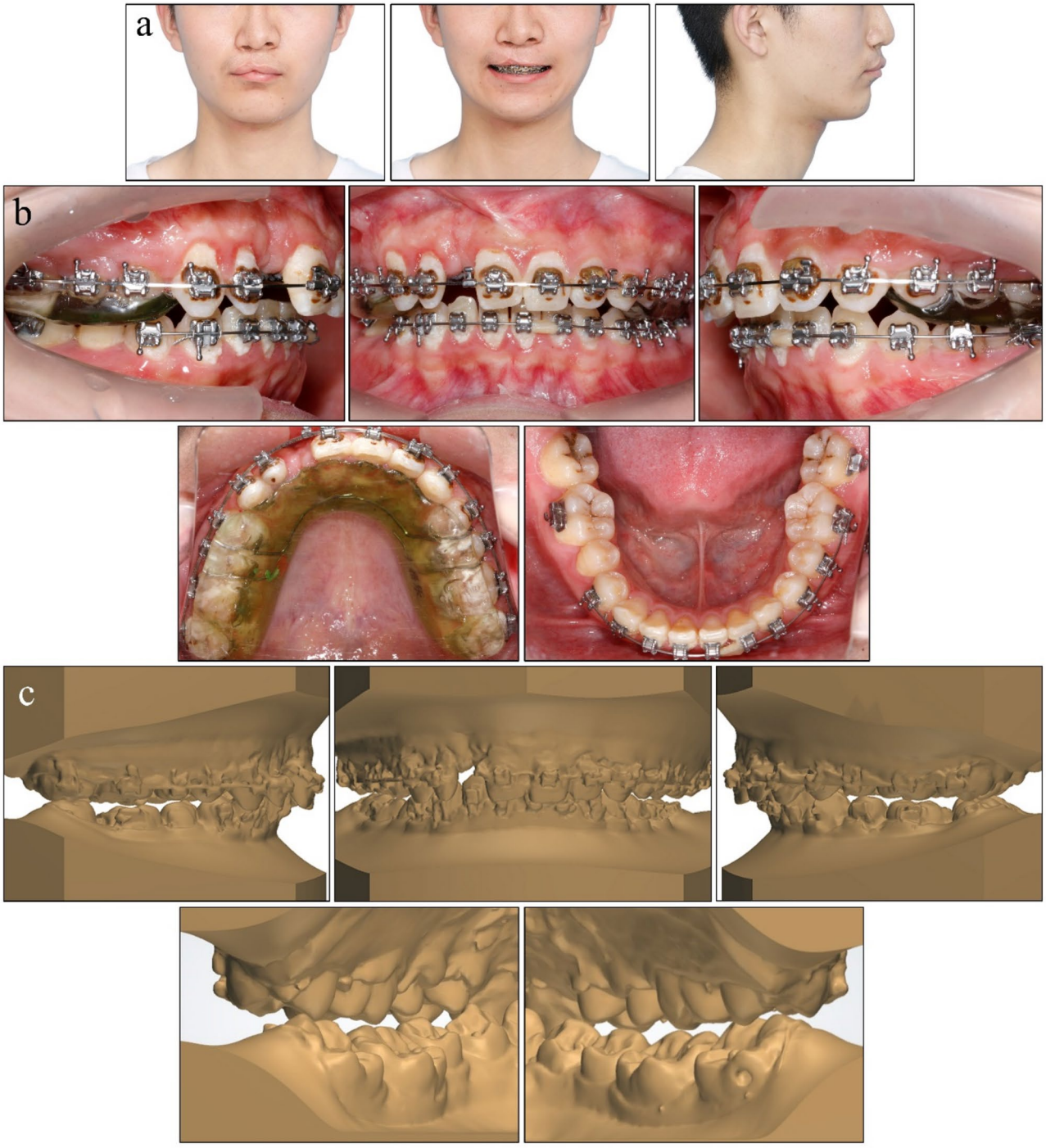


Fig. 1 Pre-retreatment examinations of the adolescent with unilateral complete cleft lip. **(a)** Pretreatment facial photographs. **(b)** Pretreatment intraoral photographs. Notably, the patient showed considerably poor oral hygiene, characterized by significant accumulation of calculus and plaque around the fixed brackets. **(c)** Pretreatment dental casts without a removable occlusal splint for the maxillary posterior teeth. The rear view displays significant discrepancies in the width of posterior teeth, including a scissor bite of the right premolars and first molars and a deep overjet of the left premolars and molars

every three months to assess the need for further in-office fluoride varnish treatments. Additionally, the patient was instructed to use toothpaste containing 5,000 ppm sodium fluoride (Colgate® PreviDent® 5000) twice daily. Crucially, the patient was provided with comprehensive and rigorous oral hygiene education to improve his dental care practices. After two months, a notable improvement in oral hygiene was observed, along with

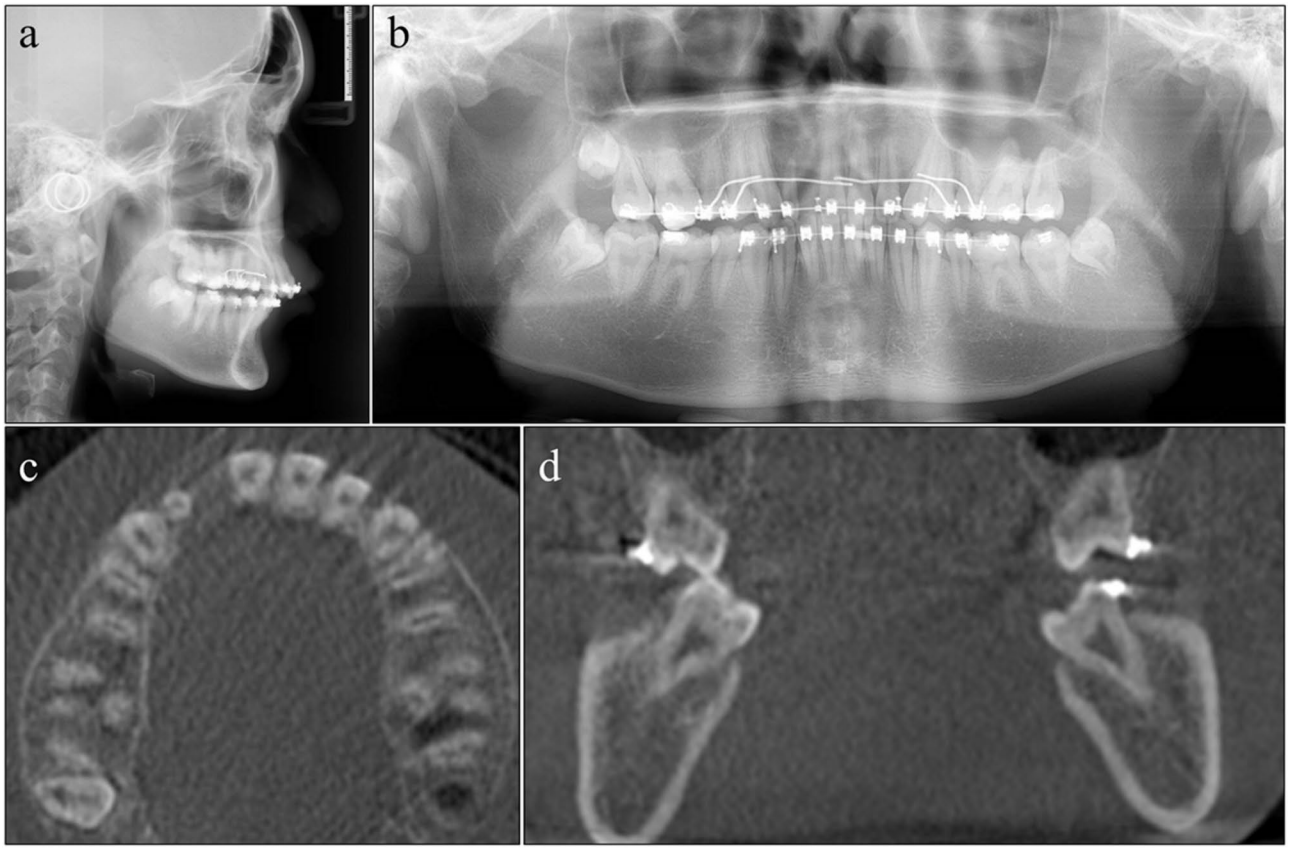


Fig. 2 Pre-retreatment lateral cephalogram, panoramic radiograph and CBCT. **(a)** Lateral cephalogram. **(b)** Panoramic radiograph. **(c-d)** CBCT. An axial slice revealing bone presence at the alveolar cleft bone graft site, located distally to the right maxillary central incisor (indicated in c), and a coronal slice at the level of the second molars showing significant discrepancies in the width of posterior teeth bilaterally (indicated in d)

Table 1 Cephalometric measurements

Measurement	Pretreatment	Posttreatment	Norm
SNA/°	80.2	79.5	82.8 ± 4.0
SNB/°	77.9	78.3	80.1 ± 3.9
ANB/°	2.2	1.3	2.7 ± 2.0
U1-NA/mm	7.7	5.9	5.1 ± 2.4
L1-NB/mm	3.1	5.1	6.7 ± 2.1
OP-SN/°	8.8	9.8	16.1 ± 5.0
GoGn-SN/°	21.9	21.4	32.5 ± 5.2
FMA/°	19.1	19.2	31.3 ± 5.0
WITS/mm	4.5	2.7	-1.4 ± 2.9
Upper Lip to E-Plane/mm	1.0	0.3	-1.4 ± 1.87
Lower Lip to E-Plane/mm	1.3	-0.4	0.6 ± 1.87

effective remineralization of the enamel (Fig. 3a). Quantitative assessments [13, 14] indicated a notable decrease in both the Oral Hygiene Index-Simplified and the Plaque Index (Table 2), confirming substantial oral hygiene improvement.

Subsequently, fixed straight wire appliances (SWA, Shinye *Inc.*, China) were bonded to the maxillary teeth, and a 0.012-inch nickel-titanium (NiTi) archwire was placed (Fig. 3a). The alignment and leveling of the upper arch were achieved through the sequential replacement of archwires, and a removable flat anterior bite plate was employed to reduce the deep overbite of the patient (Fig. 3b). By the 11th month of the orthodontic treatment, after placement of 0.018 × 0.025-inch stainless steel (SS) archwires on both arches, lingual segmental arches on the mandibular molars and additional labial crown torque on the main mandibular archwire were utilized, to correct lower molars that lingually inclined (Fig. 3c). At the 14.5-month juncture of the orthodontic treatment, with the anterior deep overbite corrected and the mandibular molars uprighted, space closure was begun using sliding mechanics (Fig. 3d). Class II elastics (1/4, 3.5 oz) were utilized to achieve Class I relationships for the canines and molars. With 12 months of further delicate adjustment, the appliances were debonded at the 26.5th month after the commencement of orthodontic treatment (Fig. 3e).

Concurrent with the orthodontic treatment, the patient underwent surgical procedures to improve nasolabial aesthetics. One month after the removal of the fixed appliances, the patient underwent veneer restoration for the microdontic right upper lateral incisor. Following an initial assessment, impressions were taken to create a

Fig. 3 Progress intraoral photos during the treatment. **(a)** The remineralization treatment was completed, and a fixed straight wire appliance (SWA) was bonded to the upper teeth, accompanied by the placement of 0.012-inch nickel-titanium (NiTi) archwire. Notably, compared to the pre-retreatment condition, a notable improvement in oral hygiene was observed, along with effective remineralization of the enamel. **(b)** 5-month stage of the orthodontic treatment. A removable flat anterior bite plate was employed to address the deep overbite, and brackets were bonded to the lower teeth. **(c)** 11-month stage of the orthodontic treatment. Lingual segmental arches were applied on the lower molars (indicated by arrowheads), and additional labial crown torque was employed to the main archwire to correct lower molars that lingually inclined. **(d)** 14.5-month stage of the orthodontic treatment. The deep anterior overbite was corrected, and the lower molars were uprighted. Space closure was begun using sliding mechanics. **(e)** 26.5-month stage of the orthodontic treatment. The fixed orthodontic appliance was removed. At this stage, aesthetic prosthodontic treatment for the microdontia of the right maxillary lateral incisor had not yet been performed

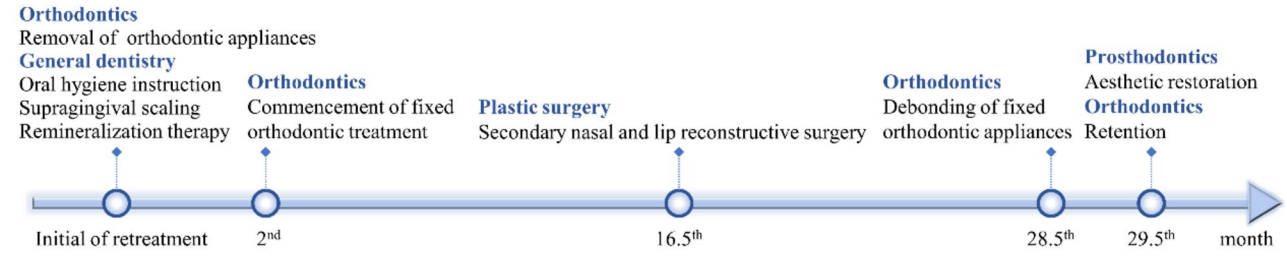
Table 2 Quantitative assessments of oral hygiene

Index	Initial Visit	Pre-Bonding	Post-Debonding
Oral Hygiene Index-Simplified	3.99	0.67	0.83
Plaque Index	2.08	0.92	1

Note: The patient's Oral Hygiene Index-Simplified and Plaque Index were assessed according to Greene and Vermillion [13] and Loe [14], respectively

diagnostic wax-up, simulating the anticipated aesthetic outcome. After evaluation and discussion, the patient approved the proposed design. Minimal tooth preparation was then performed, and an intraoral scan was conducted. CAD/CAM technology was utilized to fabricate the definitive lithium disilicate glass ceramic veneer (Ivoclar Vivadent, IPS Empress II). During the final visit, the veneer was tried in and bonded with resin cement (3M™ RelyX™ Veneer Cement). The patient was satisfied with the final aesthetic outcome. To maintain the stability of the treatment outcomes, a Hawley retainer equipped with a flat anterior bite plate was recommended for the patient (Fig. S1).

The overview of the treatment process has been summarized as a timeline, integrating multidisciplinary interventions and their corresponding rationales (Fig. 4).



Problems	Reasons	Different Specialties' Treatments	Rationale
Poor oral hygiene and tooth demineralization	·Neglect of oral hygiene instruction	·**Orthodontics**: Removal of all orthodontic appliances ·**General dentistry:** Oral hygiene instruction Remineralization therapy	·Oral hygiene is the foundation
Vertical: Deep overbite of anterior teeth	·Usage of occlusal splint for the maxillary posterior teeth	·**Orthodontics**: Using flat anterior bite plate	·Create vertical space for extrusion of posterior teeth
Transverse: Scissor bite of posterior teeth	·Insufficient vertical space for the posterior teeth to upright	·**Orthodontics**: Employing lingual segmental arches and labial crown torque on the main archwire	·Buccal and lingual dual-force system for rapid torque correction
Sagittal: Persistent space in the upper teeth	·Vertical interference in the retraction of the upper anterior teeth	·**Orthodontics**: Space closure after vertical and horizontal problems solved	·Successful bone grafting made space closure possible ·Available space to retract the anterior teeth
Aesthetic problems	·Poor dental and nasolabial aesthetics	·**Orthodontics**: Well-aligned teeth ·**Prosthodontics**: Aesthetic prosthodontics ·**Plastic surgery**: Secondary nasal and lip reconstructive surgery	·Multidisciplinary approaches to restore the aesthetics and function of the teeth and nasolabial region

Fig. 4 The timeline and detailed interventions, along with the rationale of each specialty in this retreatment case

Treatment results and follow-up

The overall active treatment duration was 29.5 months, including two months dedicated to the oral hygiene education and remineralization therapy, 26.5 months allocated for the orthodontic treatment, and one month for the aesthetic prosthodontic procedures.

After collaborative efforts among general dentistry, orthodontics, plastic surgery, and prosthodontics, the treatment objectives were achieved successfully. The adolescent's facial profile showed noticeable improvement, with an increase in the nasolabial angle and slight retraction of the upper lip, leading to a more confident smile post the treatment (Fig. 5a). Intraoral examinations indicated substantial improvements in dental health and oral hygiene following this interdisciplinary retreatment. Both maxillary and mandibular arches were in harmony, with well-aligned teeth. He achieved a bilateral Class I relationship for both canines and molars, along with an ideal overjet and overbite of anterior teeth, and excellent posterior teeth occlusion (Fig. 5b). Assessment of cephalometric measurements and superimpositions revealed retraction of the maxillary anterior teeth and slight proclination of the mandibular anterior teeth (Figs. 5c and 6; Table 1). Panoramic radiographs showed acceptable root parallelism, with exceptions being the right second lower premolar and the left upper canine. (Fig. 5d). No significant root resorption was observed during the treatment (Fig. 7). In addition, both the Oral Hygiene Index-Simplified and the Plaque Index indicated that the patient's good oral hygiene was consistently maintained throughout the treatment process (Table 2).

The patient and his parents were satisfied with the treatment outcomes. A stable occlusal relationship was maintained at the 1-year follow-up (Fig. 8).

Discussion

As a congenital anomaly, patients with CL/P are typically recommended to receive medical managements from a multidisciplinary team starting in the growth and development period [15]. This adolescent received timely interventions previously, which resulted in clear pronunciation and the absence of severe skeletal deformities. Consequently, this prevented the need for more traumatic surgeries and complex treatments later in adulthood. Even so, subsequent treatment still required timely intervention and close collaboration across multiple disciplines. At the start of this retreatment, following the debonding of the fixed appliances from the initial failed orthodontic treatment, general dentistry provided strict oral hygiene instructions and remineralization therapy,

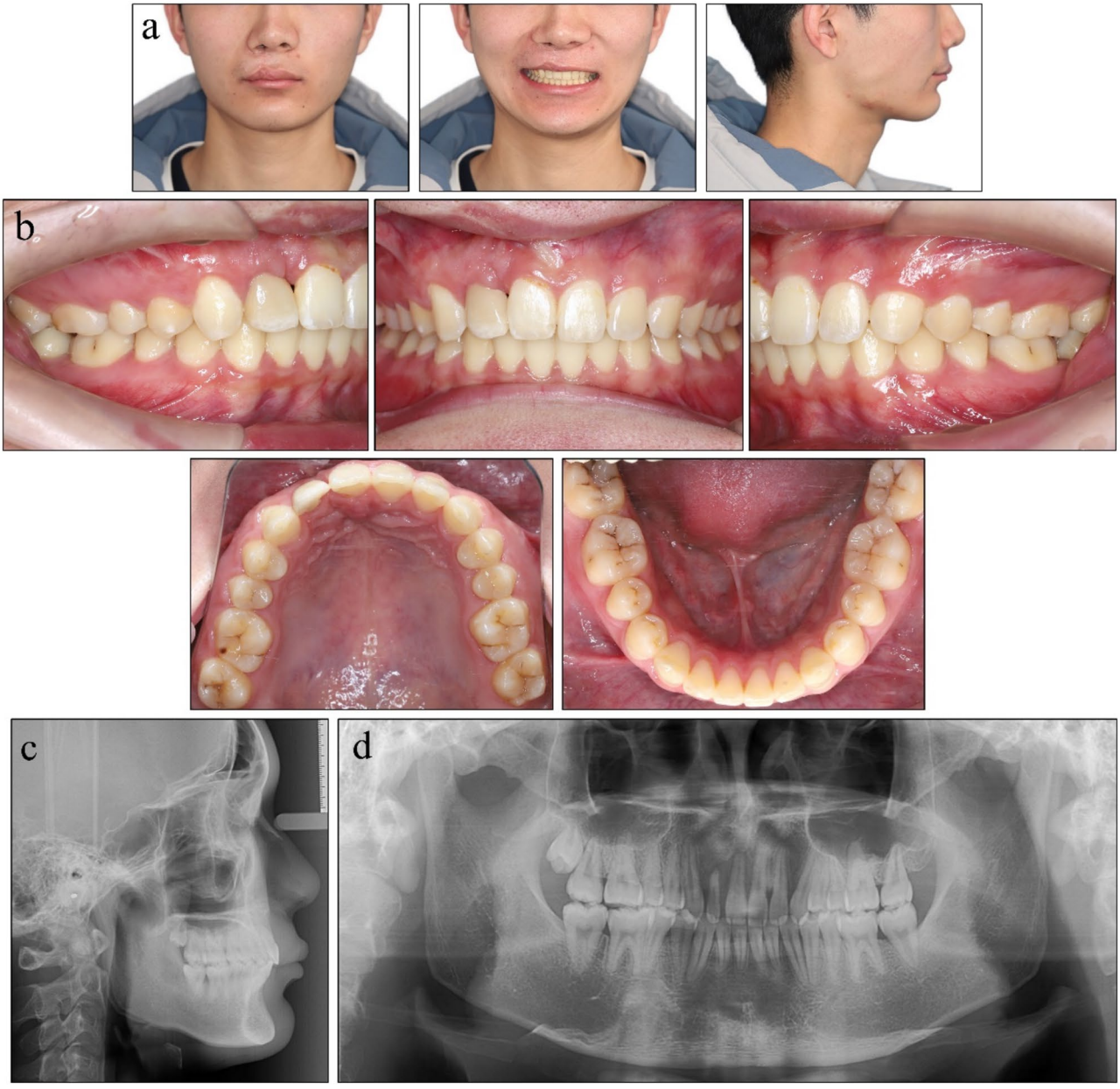


Fig. 5 Posttreatment examinations of this patient. **(a)** Posttreatment facial photographs. **(b)** Posttreatment intraoral photographs. **(c)** Posttreatment lateral cephalogram. **(d)** Posttreatment panoramic radiograph

laying the foundation for subsequent procedures. Orthodontic retreatment began with the bonding of maxillary appliances only, accompanied by a removable flat anterior bite plate to create adequate vertical space. Mandibular width adjustments were then achieved using lingual segmental arches, combined with labial crown torque on the main archwire. Only after vertical and horizontal discrepancies were resolved, space closure and occlusal adjustment were initiated. One month after debonding the fixed appliances and following stabilization of the gingival condition, aesthetic restoration was performed through prosthodontic treatment. In addition, during the mid-treatment phase, when the remaining maxillary space was limited, the patient underwent surgical revision during a holiday break to improve nasolabial aesthetics (Fig. 4).

The initial treatment presented five main issues: (1) poor oral hygiene and white spot lesions (WSLs) on the teeth, (2) deep overbite of anterior teeth, (3) severe lingual inclination of the mandibular posterior teeth, (4) persistent space of the upper arch, and (5) suboptimal dental and soft tissue aesthetics. These issues resulted from insufficient emphasis on oral hygiene instruction and an inappropriate orthodontic treatment design

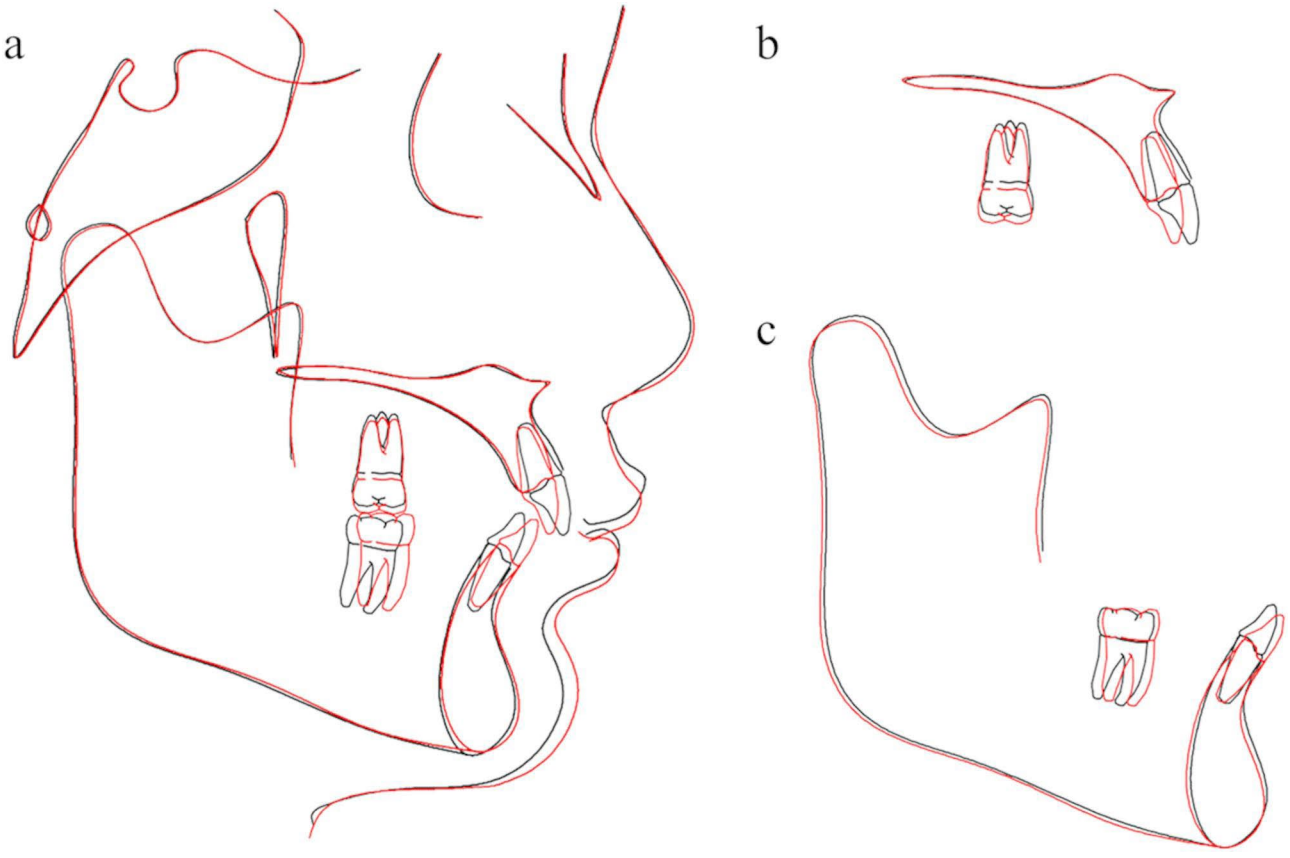


Fig. 6 Cephalometric superimposition. **(a)** The SN plane. **(b)** The maxillary plane. **(c)** The mandibular plane. Black lines indicate the pretreatment cephalometric tracing, while red lines indicate the posttreatment cephalometric tracing

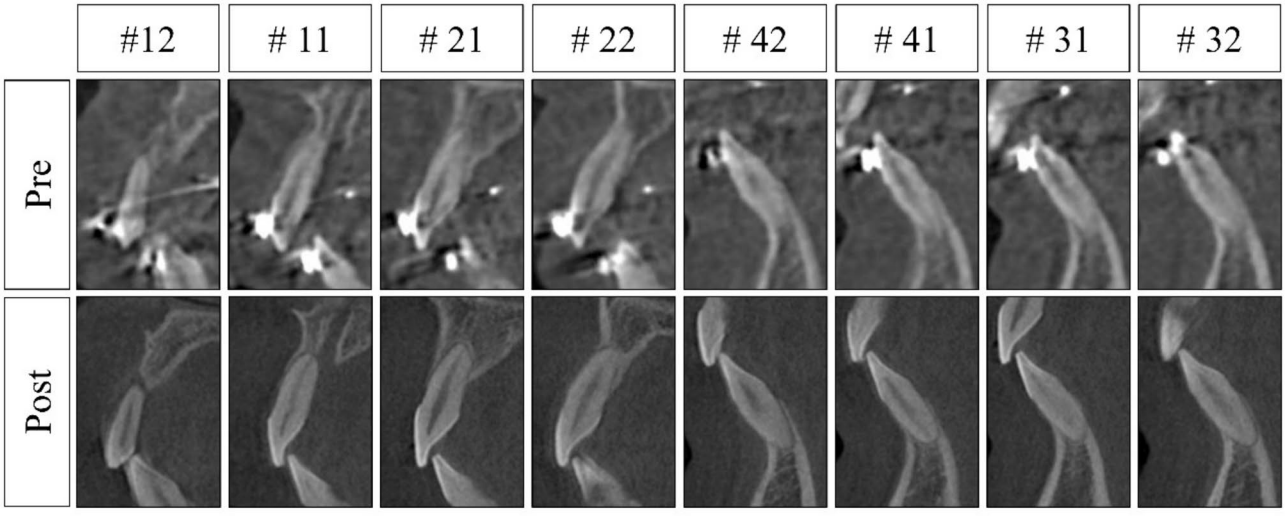


Fig. 7 CBCT slices showing the root status of the upper and lower central and lateral incisors

(Fig. 4). In the initial orthodontic treatment, the choice to use a removable occlusal splint for the maxillary posterior teeth was inappropriate. The pretreatment lateral cephalometric assessment of the adolescent indicated a low mandibular plane angle (Fig. 2a **and** Table 1). While employing an occlusal splint for the posterior teeth might have temporarily addressed the deep overbite, allowing for the bonding of brackets on the lower teeth, the ongoing intrusion forces exerted by the splint on these teeth did not contribute positively to correct the deep overbite.

Fig. 8 Facial and intraoral photographs after retention for 1 year

The unresolved deep overbite caused interference, hindering the correction of transverse and sagittal issues. Additionally, the prolonged use of the splint for the posterior teeth compromised oral hygiene of this patient. Therefore, in the subsequent orthodontic retreatment, we employed the flat anterior bite plate to create space for the posterior teeth to extend (Fig. 3b), effectively reducing the deep overbite. And, combined with multidisciplinary efforts (as illustrated in Fig. 4), we systematically and successfully addressed each issue.

Among this multidisciplinary framework, maintaining oral hygiene and providing health education are fundamental to all subsequent treatments. During the patient's initial orthodontic treatment at the other clinic, there was a notable presence of soft plaque and white-spot lesions around brackets (Fig. 1b), indicating his poor oral hygiene practices. Fortunately, conditions such as gingivitis and white-spot lesions can be reversed during this period with appropriate interventions. For this case, prior to the retreatment, it was imperative to halt the ongoing orthodontic treatment immediately. Subsequently, we applied a fluoride (F)-based remineralization therapy, currently one of the most evidence-supported methods [16], which facilitates the penetration of fluoride ions into weakened enamel to enhance its hardness by forming a stronger bond with hydroxyapatite [17]. As expected, the outcomes of the remineralization were positive, significantly improving the enamel health of the patient, which was crucial for further dental interventions. Besides fluoride-based remineralization therapy, several non-fluoride strategies serve as alternative approaches. The casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) is a commonly used non-fluoride remineralization agent, functioning as a calcium phosphate reservoir that inhibits demineralization and promotes remineralization. Additionally, its interaction with fluoride ions can form amorphous fluoridated calcium phosphate, potentially enhancing fluoride's remineralization efficacy [18]. In recent years, several new materials such as self-assembling peptides [19] and bioactive glass [20] have been introduced in remineralization therapy. These non-fluoride materials circumvent the risk of fluoride overexposure and may provide more effective alternatives for remineralization treatment. Regarding the impact of remineralization therapy on the bond strength of orthodontic brackets, while some studies suggest that topical fluoride application may reduce bond strength [21], research has shown that in demineralized enamel, topical fluoride can actually enhance the shear bond strength of brackets [22]. Moreover, excessive etching of demineralized enamel may increase the risk of enamel fragility. Therefore, we followed the standard

etching protocol during bracket bonding (35% phosphoric acid for 15 s) and used a fluoride-releasing adhesive (3M™ Transbond™ Plus). No bracket debonding was observed throughout the retreatment period.

For the severely lingually inclined molars, various strategies have been reported, such as inter-maxilla-mandible elastics, implantation of temporary skeletal anchorage devices, surgical interventions, etc [23–25]. While there are many available methods, the critical factor is to assess the availability of bone to allow tooth movement and to ensure there is no interference to the movement. In this case, after confirming that the bone volume at the buccal sides of the bilateral mandibular molars was adequate (Fig. 2d), we employed lingual segmental arches and labial crown torque on the main mandibular archwire to upright these lingually inclined molars (Fig. 3c). The narrower distance between adjacent tubes on the lingual side could produce a greater elastic deformation, generating a stronger outward force and thus speeding up the molar alignment process. Remarkably, within just three months, the severely lingually inclined lower molars were corrected and a normal overjet of posterior teeth was achieved (Fig. 3d), demonstrating the efficacy of this approach.

Closing the space due to the alveolar cleft posed another challenge in this case. CL/P patients tend to have alveolar clefts in approximately 75% of cases [26]. Previous study has revealed that alveolar bone grafting can restore the continuity and shape of the dental arch [27]. In this patient, pretreatment panoramic radiograph and CBCT indicated the success of the alveolar bone grafting (Fig. 2b and c). Through a coordinated approach of orthodontic and prosthodontic treatments, the space was successfully closed (Fig. 5), and long-term stability was achieved (Fig. 8), highlighting the critical role of alveolar bone grafting in managing patients with alveolar clefts [28].

In the sequential treatment of CL/P, timing is critical, especially for surgical intervention. Maxillary hypoplasia is a common issue in CL/P patients, often leading to severe bone and soft tissue deformities. While some patients benefit from orthodontic camouflage, around 25–60% of patients still require surgical interventions [29], such as Le Fort I surgery or distraction osteogenesis [30, 31], to correct the significant deformities. In terms of soft tissue aesthetics, despite continuous advancements in primary surgical techniques, secondary deformities remain common due to factors such as growth, scar contracture, and others. These deformities vary widely and may include hypertrophic scars, lip shortening, and irregular vermilion-cutaneous borders, often involving both superficial and deep muscle structures [32]. Consequently, surgical planning for secondary revision is more complex than that for primary surgery and requires a thorough analysis of the underlying causes. Secondary surgery can be performed either after the deformity stabilizes or during early childhood, early adolescence, or later. Early intervention can help restore orofacial function and growth potential [33]. However, ongoing facial growth may lead to scar contracture, potentially compromising long-term outcomes. Therefore, the optimal timing for secondary surgery should be thoroughly discussed with patients and their families to ensure the best possible physical and psychological outcomes. Notably, complications of secondary revision may include bleeding, hematoma, infection, scar contracture, and recurrence of deformity. Given these risks, for patients unwilling to undergo secondary surgery or those with mild deformities, minimally invasive options such as botulinum toxin injection, laser therapy, or fat grafting [34] can be considered, offering alternatives to reduce scarring and improve aesthetics.

Conclusions

Here, we present a retreatment of an adolescent with UCCL, who, during his initial orthodontic treatment at another dental clinic, exhibited poor oral hygiene, deep overbite of anterior teeth, significant discrepancies in the width of posterior teeth, and persistent spaces resulting from alveolar cleft. A comprehensive, interdisciplinary strategy involving remineralization, orthodontics, prosthodontics, and surgical interventions, led to marked improvements in the patient's oral hygiene and occlusion, alongside dental and facial aesthetics. This case report emphasizes the pivotal role of effective oral hygiene management and interdisciplinary collaboration among dental subspecialties in the treatment of CL/P patients.

Abbreviations

CL/P	Cleft lip and/or palate
NiTi	Nickel-titanium
SS	Stainless-steel
SWA	Straight wire appliance
UCCL	Unilateral complete cleft lip

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12903-025-06055-6.

Supplementary Material 1

Acknowledgements

We thank the patient participating in this study.

Author contributions

Huaxiang Zhao, Yuhua Jiao, and Yuxia Hou conducted the orthodontic treatment; Chunhui Zhu performed the tooth remineralization accompanied by instructions for oral hygiene; Yongwei Tao and Zhanping Ren led the surgical intervention; Wenzhi Du conducted the prosthodontic work; Huaxiang Zhao, Yuhua Jiao, Yongwei Tao, and Yuxia Hou wrote the manuscript; Huaxiang Zhao and Yuxia Hou revised the manuscript.

Funding
This study was supported by National Natural Science Foundation of China (No. 82370909 to Yuxia Hou and No. 82001030 to Huaxiang Zhao).

Data availability
All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate
This work has been registered in and approved by Clinical Research Center of Shaanxi Province for Dental and Maxillofacial Diseases (Clinical Trial Number: xjkqll[2019]No.014). Informed consent was obtained from the patient and his parents.

Consent for publication
Written informed consent and authorization for publishing identifiable facial photographs & details of the treatment were obtained from the patient and his parents.

Competing interests
The authors declare no competing interests.

Received: 8 July 2024 / Accepted: 24 April 2025
Published online: 01 May 2025

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