Case Report

Anterior retraction with a canine implant in the way using clear aligner: a case report

Xu Zhang[a]; Pochun Lin[b]; Naiqi Liao[a]; Quan Yuan[c]; Yu Li[d]

ABSTRACT

Objective: A 26-year-old woman came for orthodontic treatment to improve her profile with protrusive lips. Diagnosed as bimaxillary protrusion, extraction followed by anterior retraction was indispensable for the case. However, her left upper lateral incisor was absent, the left upper canine had moved mesially and replaced the adjacent incisor, and the original canine location was restored with a long implant, which was in good condition. Surgical removal of the implant would be tricky and might lead to atrophy of the alveolar bone. In addition, the upper left central incisor had a short, curved root, which could not undergo significant movement.

Materials and Methods: After crucial discussion between orthodontists and implantologists, based on digital setup, an innovative treatment plan was developed. Four incisors were extracted followed by clear aligner therapy for anterior retraction. An individualized zirconia abutment was installed on the upper left implant in a retroclined direction, cemented with a zirconia crown to replace the upper lateral incisor. Minimally invasive veneers were made to reshape the other upper incisors for better esthetics.

Results: Finally, the patient had her profile greatly improved and the teeth well aligned without removal of the implant.

Conclusion: Thus, the seemingly mission impossible was accomplished with a satisfactory outcome, thanks to imaginative treatment planning and delicate interdisciplinary collaboration based on digital simulation. (*Angle Orthod*. 0000;00:000–000.)

KEY WORDS: Interdisciplinary treatment; Clear aligner; Bimaxillary protrusion; Incisor extraction; Implant

INTRODUCTION

Improving profile esthetics is a major motivation of orthodontic patients, particularly for those with orofacial deformities like bimaxillary protrusion. The primary objectives of orthodontic intervention for bimaxillary protrusion encompass improvement of the soft tissue profile, typically through premolar extraction and anterior retraction.[1–3]

In special circumstances, unconventional tooth extraction options may be considered, which could be more challenging.[4] Benefiting from development of digital technology, dentists can now set up the dentition objective and design the tooth movement staging before initiating the real treatment. Digital simulation has greatly enhanced control and predictability of orthodontic procedures, especially for complicated cases.

Currently, orthodontic simulation data can be imported into implant restoration design modules in software, enabling synchronous multidisciplinary design. Dentists can predict the adequacy of space for restoration after orthodontic movement, evaluate the harmony of tooth and bone volume, determine the earliest feasible timing for

The first two authors contributed equally to this work.

[a] Doctoral Student, State Key Laboratory of Oral Diseases, National Center for Stomatology, National Clinical Research Center for Oral Diseases, Department of Orthodontics, West China Hospital of Stomatology, Sichuan University, Chengdu, China.

[b] Doctoral Student, State Key Laboratory of Oral Diseases, National Center for Stomatology, National Clinical Research Center for Oral Diseases, Department of Oral Implantology, West China Hospital of Stomatology, Sichuan University, Chengdu, China.

[c] Professor, State Key Laboratory of Oral Diseases, National Center for Stomatology, National Clinical Research Center for Oral Diseases, Department of Oral Implantology, West China Hospital of Stomatology, Sichuan University, Chengdu, China.

[d] Professor, State Key Laboratory of Oral Diseases, National Center for Stomatology, National Clinical Research Center for Oral Diseases, Department of Orthodontics, West China Hospital of Stomatology, Sichuan University, Chengdu, China.

Corresponding author: Dr Yu Li, State Key Laboratory of Oral Diseases, National Center for Stomatology, National Clinical Research Center for Oral Diseases, Department of Orthodontics, West China Hospital of Stomatology, Sichuan University, Chengdu, 610041, China
(e-mail: yuli@scu.edu.cn)

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Figure 1. Pretreatment facial and intraoral photographs.

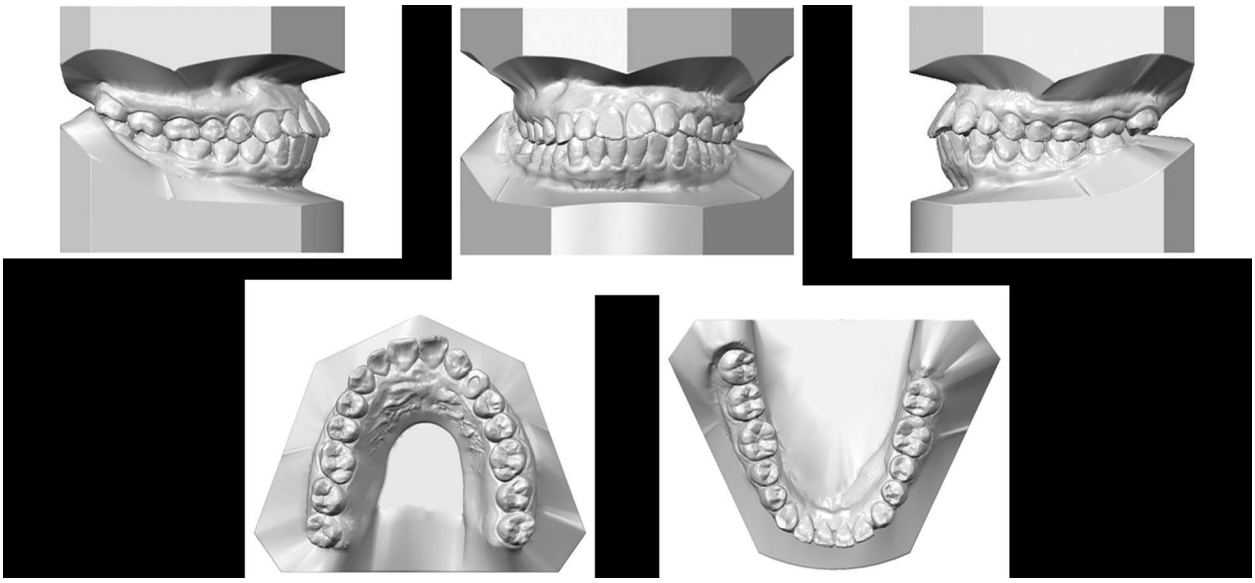

Figure 2. Pretreatment dental casts.

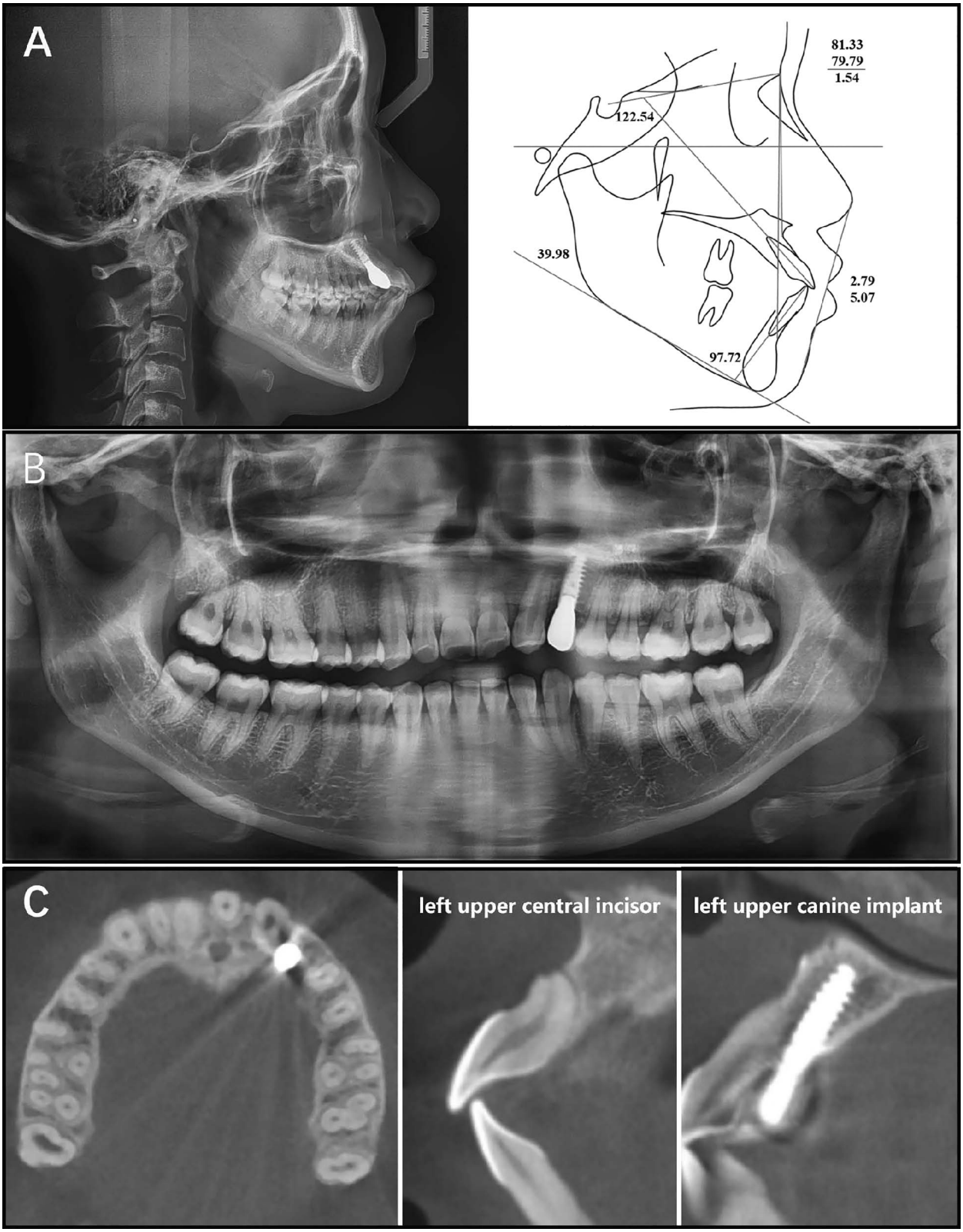

Figure 3. Pretreatment radiographs. (A) Lateral cephalogram with tracing. (B) Panoramic radiograph. (C) CBCT. CBCT indicates cone beam computed tomography.

Table 1. Cephalometric Analysis Measures Before and After Treatment

Measurement	Pretreatment	Posttreatment	Norm
SNA (°)	81.33	80.91	83.0
SNB (°)	79.79	79.1	80.0
ANB (°)	1.54	1.8	3.0
SN-MP (°)	39.98	40.68	30.0
FMA (°)	30.51	31.3	26.0
U1-NA (mm)	10.74	3.84	5.0
U1-SN (°)	122.54	105.12	106.0
L1-NB (mm)	10.38	2.41	7.0
IMPA (°)	97.72	76.04	97.0
UL-EP (mm)	2.79	0.58	−1.0
LL-EP (mm)	5.07	0.65	1.0

implant placement based on the tooth movement, and assess whether previously placed implants can be preserved for subsequent restoration.[5,6] Such streamlined communication with patients regarding the outcome significantly shortens treatment duration in appropriate cases.

This paper is a report of an unconventional case, which was completed by using imaginative treatment planning based on digital simulation and delicate interdisciplinary collaboration between orthodontics and implant prosthodontics.

Diagnosis and Etiology

The patient was a 26-year-old female who presented with a chief complaint of protrusion and a preference for orthodontic treatment using clear aligners.

She had undergone orthodontic treatment once in her adolescence, including traction of some impacted teeth as she recalled. About 5 years previously, one of her upper left anterior teeth fell out, and she had a canine implant installed at another medical facility. At that time, she didn't care too much about the protrusion. Now she was concerned about the protrusion and pursued orthodontic treatment for improvement.

The pretreatment facial photographs (Figure 1) showed that the patient had a mesofacial type, a low smile line, and a convex profile accompanied by protrusive upper and lower lips. Additionally, her maxillary and mandibular dental midlines deviated 1.5 mm to the right of the facial midline.

The intraoral photographs (Figure 1) and dental casts (Figure 2) showed that the patient had a permanent dentition with Class I molar relationship. Notably, the upper left lateral incisor was absent, and the upper left canine had moved mesially and was substituting for it. An implant restoration took the place of the upper left canine. Cast analysis demonstrated mild maxillary crowding and mild mandibular spacing.

The oral panoramic radiograph revealed a fair periodontal condition with three third molars erupted (Figure 3). The lateral cephalometric analysis indicated a skeletal Class I relationship, a high mandibular plane angle, and protrusion of the upper and lower central incisors (Figure 3, Table 1). Cone-beam computed tomography (CBCT) showed a short and curved root of the upper left central incisor, as well as a long implant (NobelActive, 3.5 × 13 mm) at the original position of the upper left canine (Figure 3).

The patient was diagnosed as having a Class I malocclusion with bimaxillary protrusion, and skeletal Class I with a high mandibular plane angle.

Treatment Objectives

The treatment objectives for this patient were to improve the facial profile by retraction of the anterior

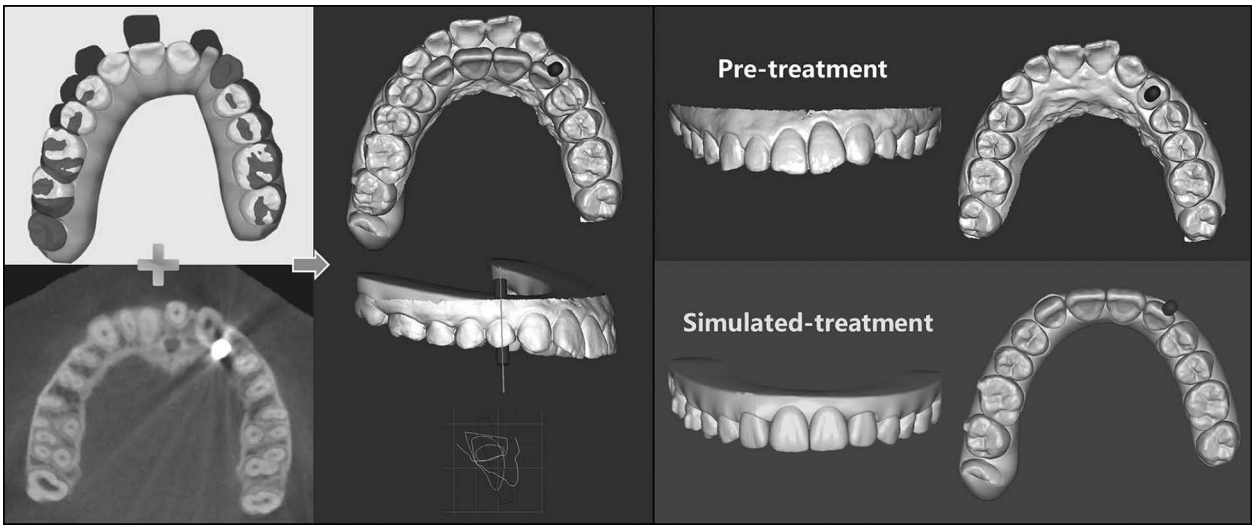

Figure 4. Digital design and treatment simulation.

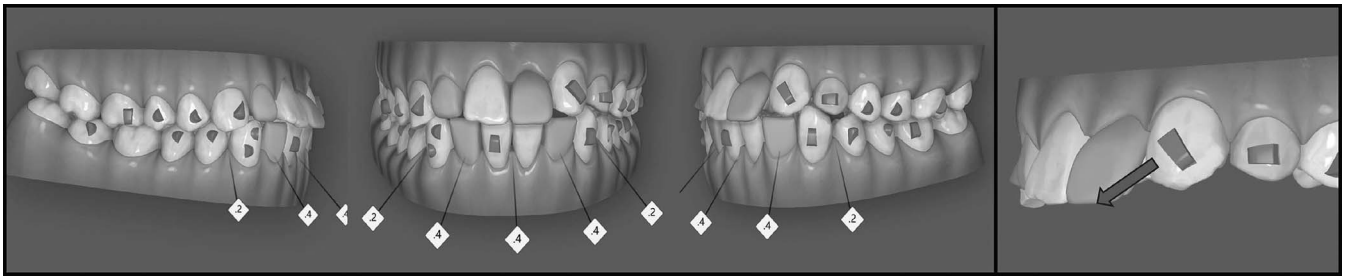

Figure 5. The ClinCheck for the R0 treatment. Notably, an "oblique attachment" was put on the upper left canine to facilitate mesialization and extrusion of the tooth as the arrow shows.

teeth, followed by prosthodontic treatment to enhance anterior dental esthetics.

Treatment Plan Alternatives

To accomplish the objectives, two alternative treatment plans were considered.

Plan A: Extract the upper right first premolar and two mandibular first premolars, and remove the upper left canine implant and, then, close the spaces by retracting the anterior teeth using miniscrew-assisted anchorage, if necessary.

That plan had two apparent drawbacks. First, the canine implant was long and displayed good osseointegration, with the apex close to the nasal base (Figure 3). Consequently, it would be a tough task to take out the implant, necessitating removal of a certain amount of surrounding bone, with risk of injuring the nasal base and causing postsurgical alveolar bone atrophy. Also, the left upper central incisor with a very short and curved root might not survive substantial retraction.

Plan B: Extract the handicapped upper left central incisor as well as the upper right lateral incisor and two mandibular lateral incisors, followed by closing the spaces with anterior retraction. After the orthodontic treatment, the upper right canine would replace the upper right lateral incisor, the upper left canine would replace the upper left central incisor, and the upper left implant restoration would be redirected and reshaped as the upper left lateral incisor. This plan facilitated a large amount of anterior retraction with removal of the upper left central incisor with a short root, and removal of the long implant was also avoided.

However, there was cause for uncertainty in this plan: Would the implant restoration be well-aligned in the post-treatment dental arch? After prudent study of the simulated orthodontic and prosthodontic treatment (Figure 4), the orthodontists and implantologists tended to support that a new restoration could probably be made on the implant to fit in with the postorthodontic dentition.

The patient chose plan B and clear aligners (Invisalign, Align Technologies, San Jose, CA, USA) for orthodontic treatment.

Figure 6. Progress intraoral photographs at the first month of the R0 treatment.

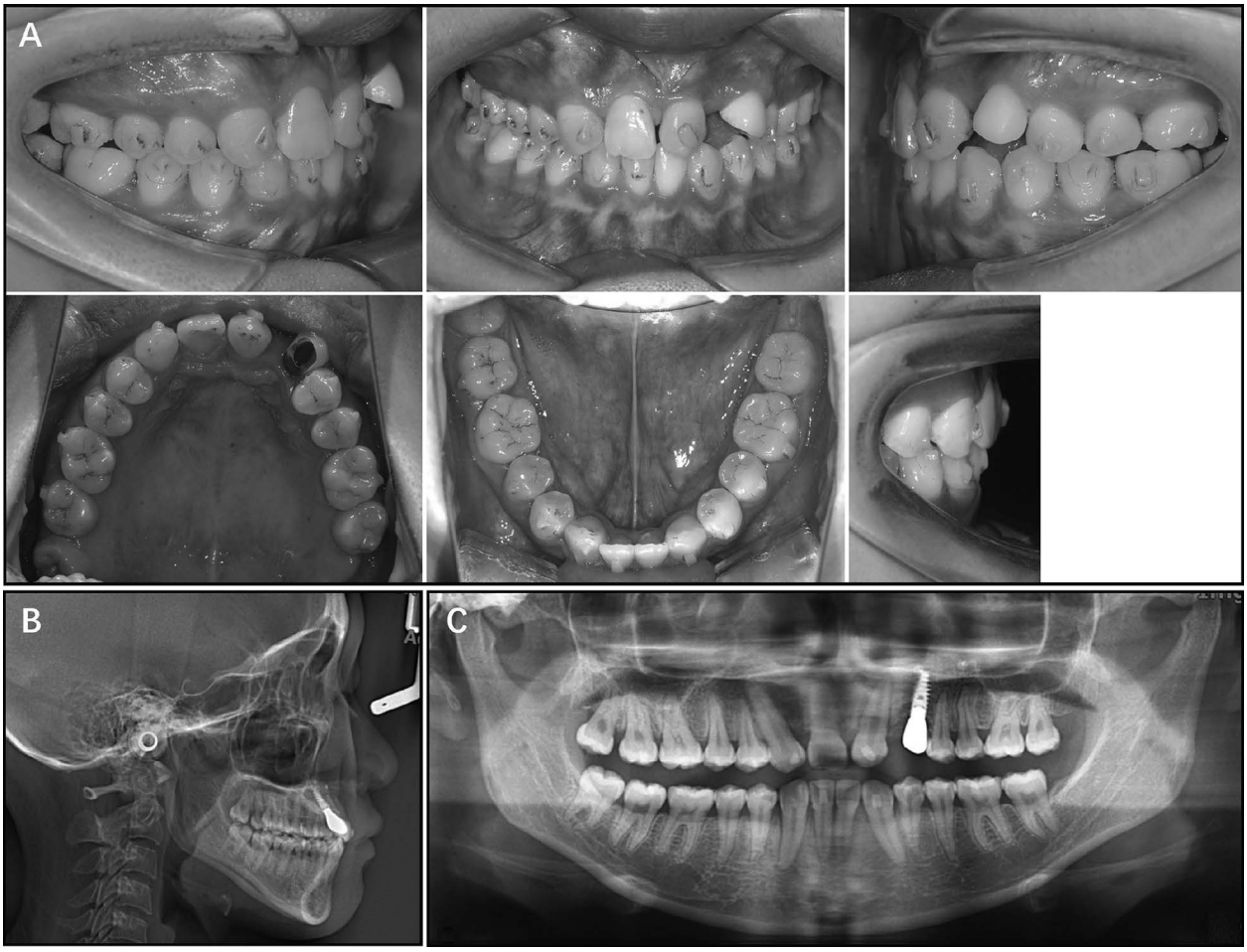

Figure 7. Records at the 16th month of the R0 treatment. (A) Intraoral photographs. (B) Lateral cephalogram. (C) Panoramic radiograph.

Treatment Progress

The intraoral scanner (iTero Element, Align Technologies, San Jose, CA, USA) provided a 3D dataset. The ClinCheck system was used for setup and design of attachments and staging. The treatment was completed in two phases: the initial treatment (R0) and the first refinement (R1). The patient was seen every 1–2 months during the treatment process to monitor oral hygiene and aligner conformity.

Initial Treatment Phase (R0)

The ClinCheck image for R0 is shown in Figure 5. Notably, a rectangular attachment of 4 mm was put on the left upper canine with an angulation of about 45° to the crown facial axis. As the large mesial movement of this canine would be challenging, the orthodontist (YL) specifically designed such an "oblique attachment" with the speculation that it might assist mesial and extrusive movements, preventing dislodging the aligner from the tooth.

The main objectives of R0 were to retract anterior teeth and close the extraction spaces (Figures 6 and 7). A total of 46 aligners were used over 16 months. The patient changed aligners every 10 days according to the orthodontist's instruction. During anterior tooth retraction, virtual pontics were used for esthetic camouflage of the four extracted incisors. On the 16th month, closure of the extraction spaces was completed, leaving the implant restoration exclusively outside the dental arch (Figure 7). Notably, the upper left canine moved substantially mesially and lingually, with acceptable root parallelism (Figure 7C), indicating that the oblique rectangular attachment worked well in this case.

The implantologists removed the original crown and abutment from the implant, and then a standard abutment was temporarily installed, with a resin temporary crown put on, which aligned well to the dentition (Figure 8).

First Refinement Phase (R1) and Prosthodontic Treatment

The R1 treatment was to upright the upper right canine and the lower left canine, and to adjust the

Figure 8. Intraoral photographs after replacing the temporary crown of the dental implant.

remaining space. A total of 18 aligners were used over 5 months (Figure 9).

At the end of orthodontic treatment, the final prosthetic treatment was carried out. A digital smile design was conducted and a wax-up was created in the laboratory. Then, the configuration was evaluated intraorally prior to tooth preparation (Figure 10A). The prosthodontic outcome was previewed in the patient's mouth using a mockup (Figure 10B). The restorations did not affect the protrusive and lateral guidance. Tooth preparation was guided by the mockup spot bonded to the teeth (Figure 10C). Once tooth preparation was completed, followed by polishing, a digital shade matching process was conducted using a gray card, and a final impression was taken. The final restorations, including the individualized zirconia abutment, crown and lithium disilicate veneers, were then placed (Figure 10D). With the patient's approval, the restorations were cemented individually under rubber dam isolation, using total etch adhesion and a light-cured composite following the manufacturer's instructions (Figure 10E).

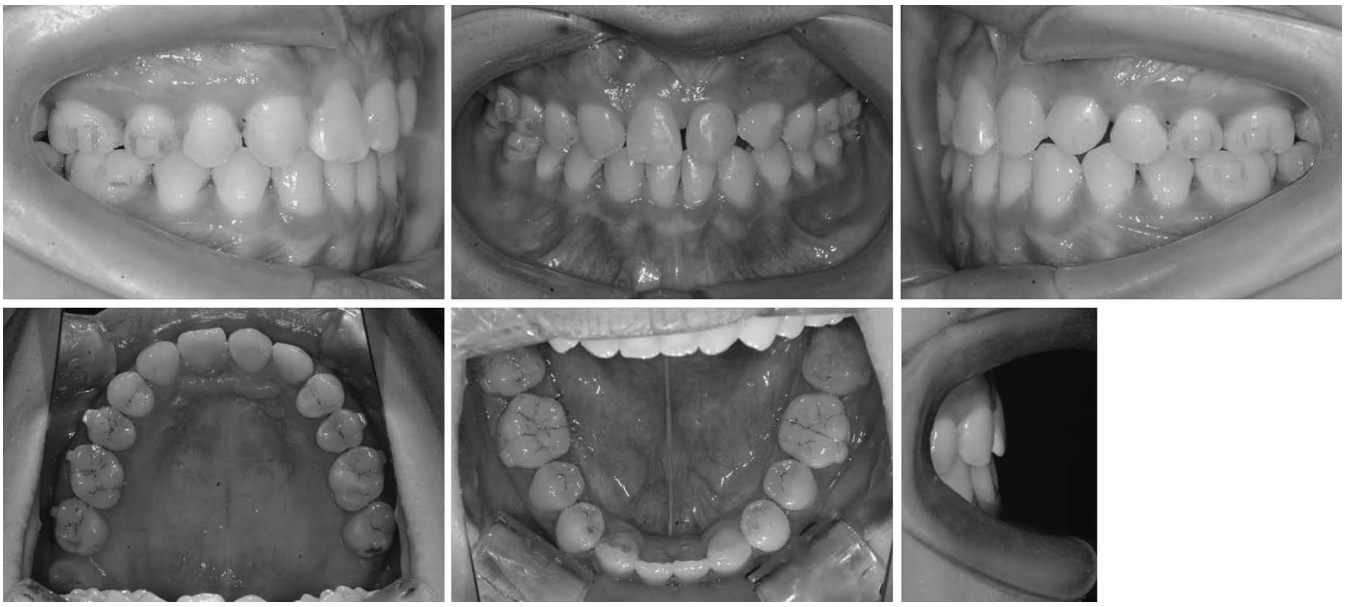

Figure 9. Intraoral photographs after first refinement.

Figure 10. The final esthetic restoration process for the anterior teeth. (A) Digital smile design; (B) Mockup; (C) Tooth preparation; (D) Zirconia custom abutment, crown, and silicon-dioxide veneers; (E) Final restoration.

Treatment Results

Orthodontic treatment spanned 21 months with a total of 64 aligners (46 + 18). After that, esthetic restoration of the four upper incisors was performed with a zirconia crown and three lithium disilicate veneers. Despite obstruction of the upper left implant, the treatment objectives were fully accomplished (Figures 11–13). In particular, the incisors were retracted, resulting in reduced lip protrusion and improved profile esthetics (Table 1, Figures 13 and 14). Additionally, the upper and lower midlines coincided with the facial midline. The patient demonstrated compliance with wearing clear aligners and expressed satisfaction with the treatment results. Overall, efficient treatment and a satisfactory outcome were achieved in this unconventional case.

Retention

Transparent, full-arch wraparound retainers were used for both arches. The patient was instructed to wear them full time for the first year posttreatment and only at night for the second year. Instructions were provided for home care, as well as for maintenance of the retainers. Follow-up records were collected 15 months after the treatment finished, with stable results observed (Figure 15).

DISCUSSION

This case involved a presentation with bimaxillary protrusion, a malocclusion usually treated by extracting four premolars to facilitate anterior retraction. However, a dental implant at the canine position complicated the situation. One common option is to extract the implant. However, due to the long implant and its proximity to the nasal base, considerable risks were anticipated with bone removal for implant extraction, potentially leading to postoperative alveolar bone atrophy. Among the existing techniques, the reverse torque technique is considered the most conservative to remove osseointegrated implants, which may have the following drawbacks: first, there is over a 12% failure rate; second, in certain cases, it may lead to implant fracture or bone fragment detachment, especially when appropriate explantation devices are unavailable.[7] When the reverse torque technique fails, drilling or piezosurgery could be considered; however, these methods may result in greater bone loss.

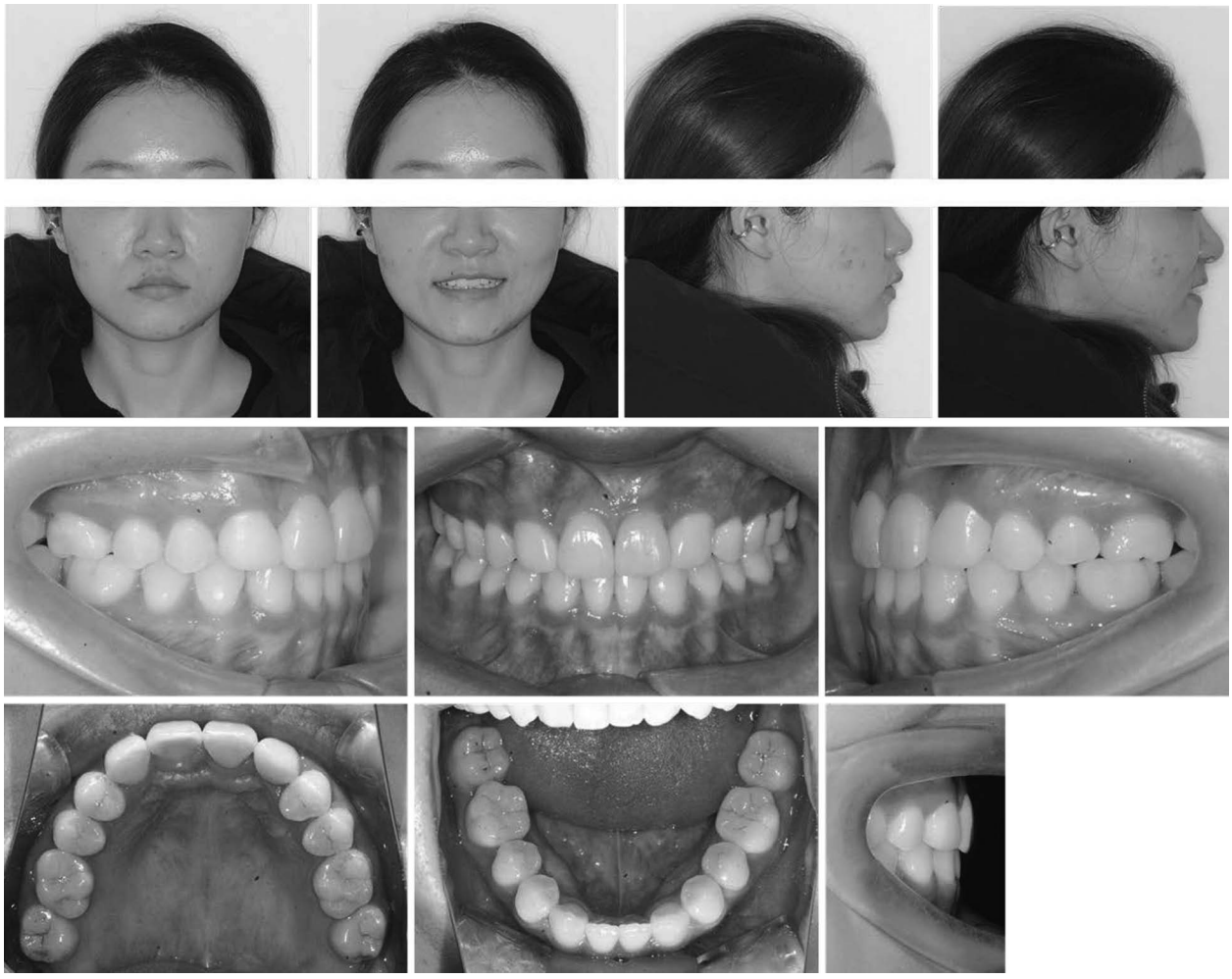

Figure 11. Posttreatment facial and intraoral photographs.

An alternative strategy was extraction of the incisors for retraction, avoiding obstruction of the canine implant. Usually, it would be preferable to extract the lateral rather than the central incisors. However, the short and curved root of the left upper central incisor made it unsuitable for long-distance retraction. Therefore, extraction of the left upper central incisor was planned, which not only removed the handicapped tooth but also ensured effective anterior retraction.

Since the implant could not be moved, the upper left lateral incisor to be restored on the implant would be much wider than the natural upper right lateral incisor. Therefore, the upper right lateral incisor was planned to be extracted, with the adjacent, wider canine as its substitute. The final prosthodontic outcome demonstrated symmetric upper lateral incisors, which supported the present treatment plan. Another option was to extract the upper right first premolar, which might have fallen short in the following ways: first, the upper right lateral incisor would still have needed a crown to increase its width; second, the upper right canine would have been asymmetric to the upper left first premolar (at the canine site); third, a miniscrew would have to be used to enhance posterior anchorage on the right side, which was avoided in the present treatment plan.

In the lower arch, there were also options: to extract the incisors or premolars. The patient originally had a Class I molar relationship on both sides, with good intercuspation. Since two upper incisors were to be extracted, extraction of two lower incisors would have facilitated keeping the original occlusion. If two lower first premolars were extracted, intercuspation would have to be reestablished between the upper first premolars (serving as the canines) and the lower canines, which would require recontouring of these teeth. In adult orthodontic treatment, unnecessary changes to the well-adapted intercuspation should be avoided if possible. Additionally, extraction of the lower premolars might also necessitate use of miniscrews to enhance the posterior anchorage.

Success of the present treatment plan can be primarily attributed to two factors. First, due to the pronounced bimaxillary protrusion, it was determined that

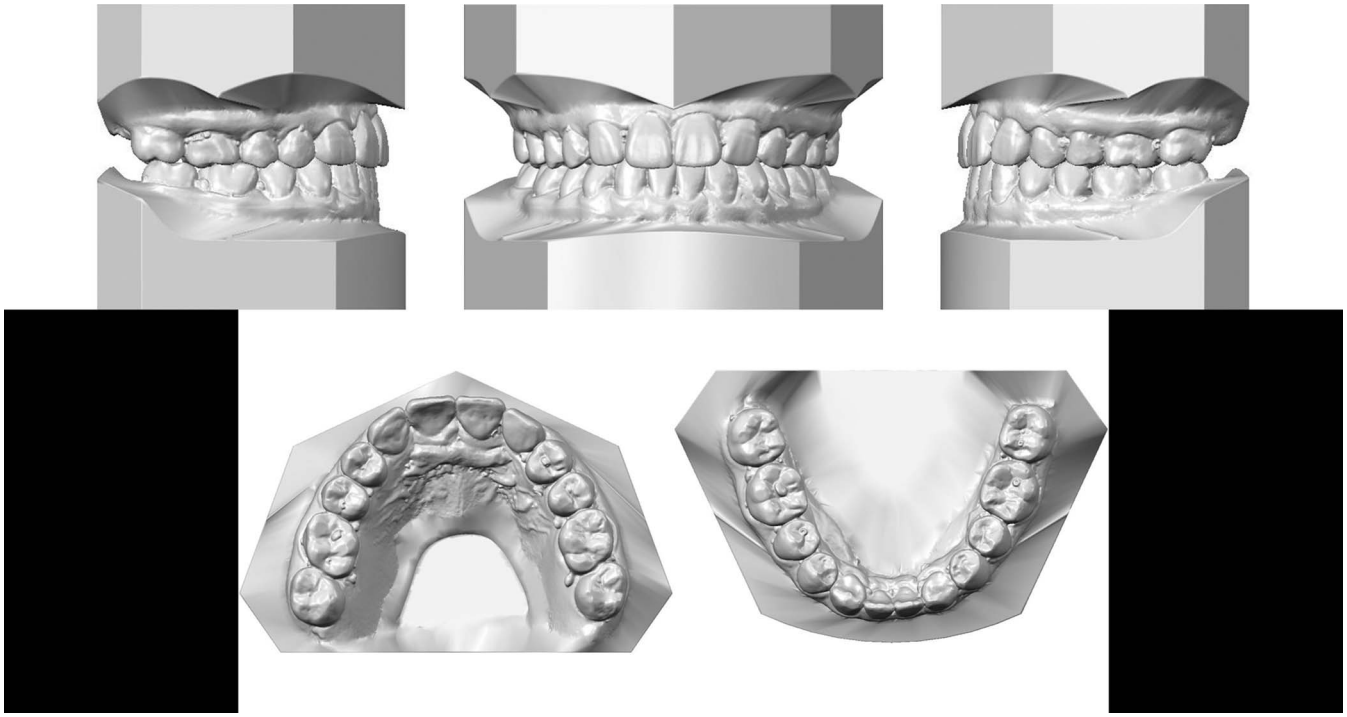

Figure 12. Posttreatment dental casts.

the left upper posterior teeth needed almost no mesial movement. This allowed set-up of a treatment objective involving the greatest amount of anterior retraction to close the extraction spaces. Second, after the orthodontic treatment, palatal movement of the upper anterior teeth was anticipated and, luckily, the implant was positioned palatally in the alveolar bone, which increased the chance of success of repositioning the implant crown to fit in the postorthodontic dentition. In this case, the orthodontist and the implantologist thoroughly considered these factors and devised a comprehensive treatment plan, which was successful in the end.

In cases of upper incisor extraction, delicate tooth positioning should be considered for a better esthetic outcome. In fixed orthodontic treatment, if an upper canine is to replace the lateral incisor, it should be bonded with the preadjusted bracket of the lateral incisor, which includes palatal root torque as the lateral incisor requires.[8] In addition, gingival margins of the upper canines and central incisors are almost at the same height, whereas those of the first premolars and lateral incisors are lower. Therefore, individualized canine extrusion and premolar intrusion may be necessary during their mesial positioning.[4] In clear aligner therapy, these details should be considered in the digital setup of the final dentition.

Another issue worth mentioning is posttreatment lateral guidance. Since no upper canines remained, there was no canine protected occlusion after the orthodontic treatment. The deviation from canine protected occlusion to group function occlusion after extraction of an upper central incisor has been well elaborated in a previous case report.[8] In the present case, careful intraoral examination was done to make sure that there was no occlusal interference during lateral excursion. In addition, the patient did not complain about any occlusal problem in the retention period, during which dental alignment was stable. Therefore, a suitable functional occlusion was established for the patient.

The implantologist in this case utilized a personalized zirconia adhesive abutment to avoid exposure of the metal prefabricated abutment at the gingival margin, and to reshape the peri-implant gingiva, promoting periodontal esthetics. Previous studies demonstrated that utilization of personalized CAD/CAM healing abutments in an immediate protocol could notably enhance preservation of peri-implant marginal bone and soft tissue.[9,10] Various studies have shown successful osseointegration and long-term function of single-tooth implant-supported restorations.[11–14] Compared to conventional prefabricated abutments, custom-made zirconia abutments associated with all-ceramic restorations may be used to achieve superior esthetic outcomes.[15–17] Personalized zirconia abutments are white, and personalized titanium abutments treated with surface gold spraying exhibit a warm color tone, reducing the color discrepancy between the peri-implant soft tissue and the natural gingiva.[18–20]

The posttreatment panoramic radiograph revealed a slight mesial inclination of the right upper canine, representing a minor flaw of this case. The long root of the

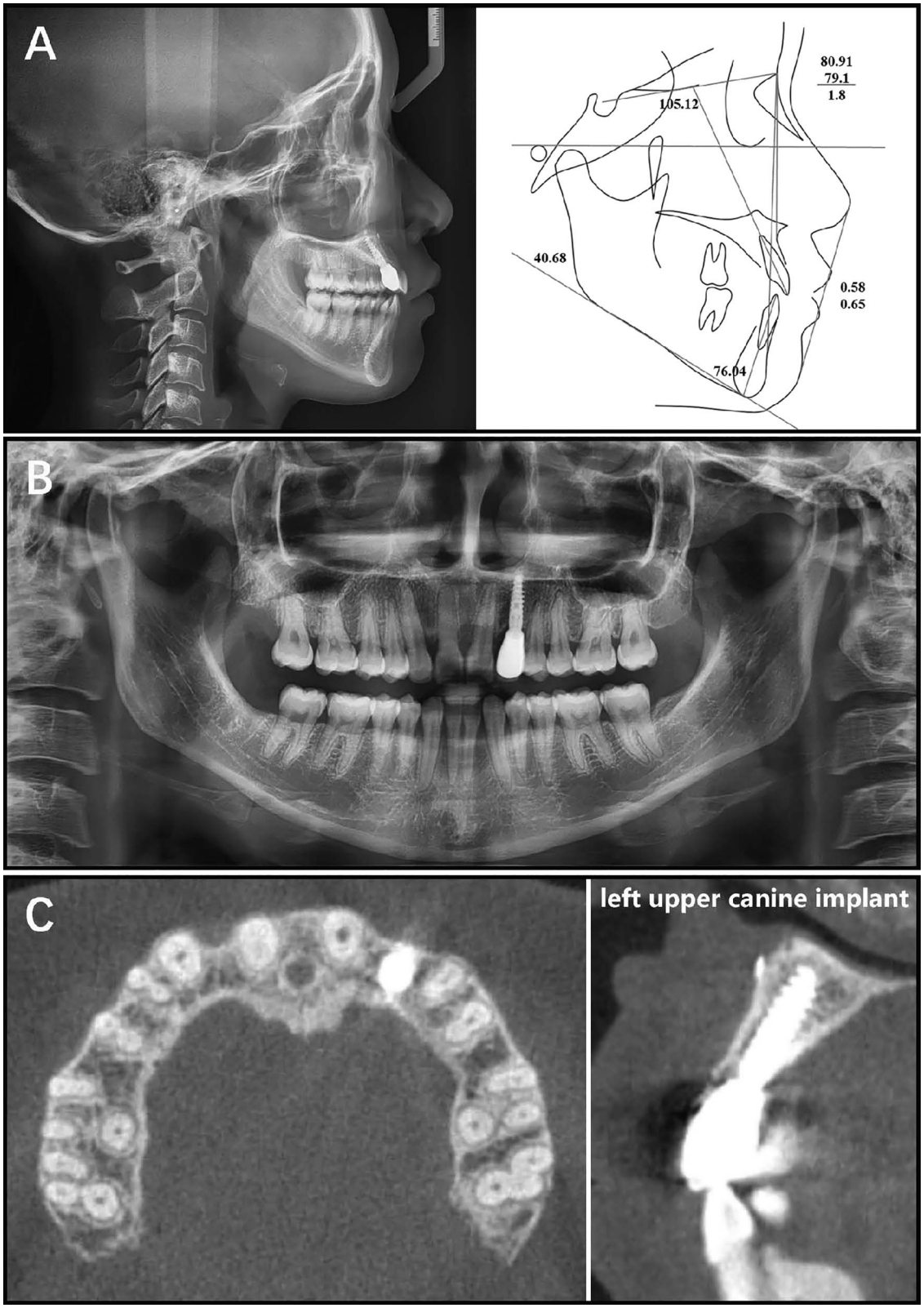

Figure 13. Posttreatment radiographs. (A) lateral cephalogram with tracing; (B) panoramic radiograph; (C) CBCT. CBCT indicates cone beam computed tomography.

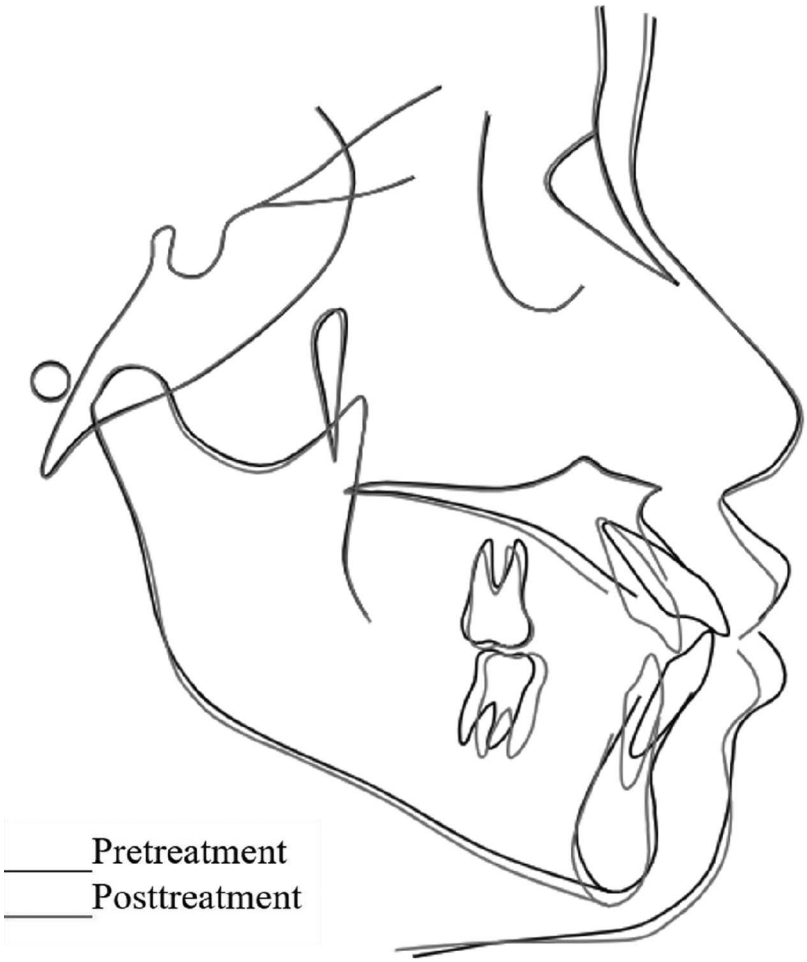

Figure 14. Cephalometric superimposition of the post-treatment (light-black line) and the pretreatment (deep-black line).

Figure 15. 15-month posttreatment intraoral photographs.

canine posed a big challenge for achieving ideal root movement, especially with clear aligners alone. Adjunctive approaches such as segmental archwires or power arm traction could be used to improve this imperfection.

CONCLUSIONS

- This presentation demonstrates a successful interdisciplinary treatment of an unconventional case with an imaginative strategy.
- Pretreatment digital simulation, individualized treatment planning, and pertinent interdisciplinary collaboration can effectively promote treatment quality and maximize patient benefits, especially when facing complicated cases.

REFERENCES

1. Feldens CA, Nakamura EK, Tessarollo FR, Closs LQ. Desire for orthodontic treatment and associated factors among adolescents in Southern Brazil. *Angle Orthod*. 2015; 85(2):224–232.
2. Leonardi R, Annunziata A, Licciardello V, Barbato E. Soft tissue changes following the extraction of premolars in non-growing patients with bimaxillary protrusion. A systematic review. *Angle Orthod.* 2010;80(1):211–216.
3. Solem RC, Marasco R, Guiterrez-Pulido L, Nielsen I, Kim SH, Nelson G. Three-dimensional soft-tissue and hard-tissue changes in the treatment of bimaxillary protrusion. *Am J Orthod Dentofacial Orthop.* 2013;144(2):218–228.
4. Mirabella D, Macca U, Pancari C, Giunta G, Lombardo L. Detailed three-dimensional orthodontic tooth repositioning to improve restorative outcome. *Angle Orthod.* 2022;92(3): 415–425.
5. Oliveira DD, de Oliveira BF, da Mata Cid Pinto LS, Figueiredo DS, Pithon MM, Seraidarian PI. Interdisciplinary treatment of a class III patient with congenitally absent maxillary lateral incisors. *J Esthet Restor Dent.* 2013;25(4):242–253.
6. Taner TU, Germec D, Er N, Tulunoglu I. Interdisciplinary treatment of an adult patient with old extraction sites. *Angle Orthod.* 2006;76(6):1066–1073.
7. Roy M, Loutan L, Garavaglia G, Hashim D. Removal of osseointegrated dental implants: a systematic review of explantation techniques. *Clin Oral Investig.* 2020;24(1):47–60.
8. Sano N, Sano R, Ohtani J, et al. Entire dental arch mesial movement after extraction of maxillary right central incisor due to root fracture treated with temporary anchorage devices. *Bull Tokyo Dent Coll*. 2024;65(1):19–27.
9. Menchini-Fabris GB, Crespi R, Toti P, Crespi G, Rubino L, Covani U. A 3-year retrospective study of fresh socket implants: CAD/CAM customized healing abutment vs cover screws. *Int J Comput Dent.* 2020;23(2):109–117.
10. Perez A, Caiazzo A, Valente NA, Toti P, Alfonsi F, Barone A. Standard vs customized healing abutments with simultaneous bone grafting for tissue changes around immediate implants. 1-year outcomes from a randomized clinical trial. *Clin Implant Dent Relat Res.* 2020;22(1):42–53.
11. Kokich VO Jr, Kinzer GA, Janakievski J. Congenitally missing maxillary lateral incisors: restorative replacement. Counterpoint. *Am J Orthod Dentofacial Orthop.* 2011;139(4):435, 437, 439 passim.
12. Mayer TM, Hawley CE, Gunsolley JC, Feldman S. The single-tooth implant: a viable alternative for single-tooth replacement. *J Periodontol.* 2002;73(7):687–693.
13. Noack N, Willer J, Hoffmann J. Long-term results after placement of dental implants: longitudinal study of 1,964 implants over 16 years. *Int J Oral Maxillofac Implants.* 1999;14(5): 748–755.
14. Weng D, Jacobson Z, Tarnow D, et al. A prospective multicenter clinical trial of 3i machined-surface implants: results after 6 years of follow-up. *Int J Oral Maxillofac Implants.* 2003;18(3):417–423.
15. Mahn DH, Polack MA. Esthetic rehabilitation of maxillary incisors in conjunction with flapless surgical techniques, an implant zirconia crown, and porcelain veneers. *J Esthet Restor Dent.* 2009;21(5):294–302.
16. Wang L, Wang T, Lu Y, Fan Z. Comparing the clinical outcome of peri-implant hard and soft tissue treated with immediate individualized CAD/CAM healing abutments and conventional healing abutments for single-tooth implants in esthetic areas over 12 months: a randomized clinical trial. *Int J Oral Maxillofac Implants.* 2021;36(5): 977–984.
17. Gamborena I, Sasaki Y, Blatz MB. Predictable immediate implant placement and restoration in the esthetic zone. *J Esthet Restor Dent.* 2021;33(1):158–172.
18. Watkin A, Kerstein RB. Improving darkened anterior peri-implant tissue color with zirconia custom implant abutments. *Compend Contin Educ Dent.* 2008;29(4):238–240, 242.
19. Bressan E, Paniz G, Lops D, Corazza B, Romeo E, Favero G. Influence of abutment material on the gingival color of implant-supported all-ceramic restorations: a prospective multicenter study. *Clin Oral Implants Res.* 2011;22(6):631–637.
20. Naveau A, Rignon-Bret C, Wulfman C. Zirconia abutments in the anterior region: a systematic review of mechanical and esthetic outcomes. *J Prosthet Dent.* 2019;121(5):775–781.e1.