


Systematic development of esthetics and function in a young patient with maxillary dental aplasia

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ABSTRACT

Objectives: Full-arch rehabilitations in young patients suffering from dental agenesis should compensate for the reduced vertical dimension of occlusion and restore both esthetics and function at minimal biological cost. This requires precise planning and maximum patient compliance during the preprosthetic phase. The pretreatment period with tooth-colored splints promotes a predictable outcome of the final restorations.

Clinical considerations: Thanks to better restorative materials and adhesive techniques and increased knowledge of how to preserve sound tooth structures, prosthetic dentistry has increasingly turned toward minimally invasive procedures. The present clinical case documents a minimally/non-invasive maxillary full-arch rehabilitation of an agenesis patient with multiple dental aplasia, primary tooth persistence, and deficits in bone growth. The patient was pretreated with a tooth-colored CAD/CAM polycarbonate splint. Adequate esthetics and function were achieved by two zirconia-based single-wing adhesive fixed dental prostheses to replace the upper lateral incisors, lithium disilicate ceramic partial crowns for the posterior regions, and two feldspathic veneers for the upper central incisors.

Conclusions: Non-invasive pretreatment with a removable tooth-colored splint realizes the treatment goal simply and safely, reduces treatment time, increases predictability, and facilitates the transfer of the prototype to the final restorations. New restorative options permit the minimally invasive treatment of such patients.

CLINICAL SIGNIFICANCE

A pretreatment with a removable tooth-colored splint offers a simple and safe way to define the treatment goal, reduces treatment time, increases predictability, and facilitates the transfer of the results to the final restorations even in complex cases. New restorative options permit minimally invasive treatments of young patients with multiple dental agenesis.

KEYWORDS

aplasia, ceramics, lithium disilicate, primary tooth persistence

1 | INTRODUCTION

Dental agenesis in the primary or permanent dentition is rare and usually of unknown etiology.¹

Numerical dental anomalies can be classified as follows: *hypodontia* (one or more missing teeth/aplasia), *oligodontia* (six or more missing

teeth/aplasia), *anodontia* (complete aplasia), and *hyperdontia* (an excessive number of teeth), often combined with developmental disorders of the affected jaw.^{2,3}

Several factors might be responsible for these dental anomalies, such as genetic predilection, trauma, infection, idiopathic reasons, or metabolic disorders. Third molars, maxillary lateral incisors, and

mandibular second premolars are the teeth most frequently affected.⁴ The incidence is higher in the maxilla and in male patients than in the mandible and in female patients. The prevalence varies between 0.03% and 12.6% in the permanent dentition and poses complex challenges for the restorative dentists.^{1,5–7} How much time and effort are required depends on the type and severity of the agenesis present.

Complex cases requiring full-arch or full-mouth rehabilitations to reestablish the vertical dimension of occlusion (VDO), as well as function and esthetics, often require precise planning and good patient compliance. Patient compliance can be improved by providing an optimal preprosthetic device to anticipate future outcomes, obtaining important information about function and esthetics during the time of its use. The phase before the definitive restorations are inserted is essential to achieving the esthetic and functional treatment goals.

There are three different ways to evaluate the planned VDO in advance:

1. Removable conventional occlusal splints for a single jaw, made of transparent polymethyl methacrylate (PMMA). This splint can either be fabricated conventionally or by CAD/CAM (computer-aided design/computer-aided manufacturing). It is merely a functional medical device that provides no esthetic information and is associated with low patient compliance and continuous treatment interruptions.
2. Removable CAD/CAM fabricated tooth-colored splints are suitable for transferring the wax-up to a bimaxillary device to evaluate the wax-up information simultaneously in both jaws.⁸ Because of its high flexibility, polycarbonate is considered the material of choice.^{9–11}
3. Fixed tooth-colored PMMA restorations are adhesively bonded to the hard tooth structures or preexisting restorations and fabricated either conventionally or CAD/CAM based on the intraorally tested wax-up data.¹⁰ These PMMA restorations are close to or almost identical with the definitive restoration; they are most effective, since they represent a permanent pretreatment concept without treatment interruptions. They can also serve as an ideal preparation guide for minimally invasive hard-tissue reduction.

The innovative tooth-colored splints (b) are superior to the removable conventional occlusal splints (a) and improve patient compliance.^{8,12} Unlike option (a), option (b) provides for the transfer of the correct position of the occlusal plane and implements the occlusal concept and esthetics developed by the analytic wax-up, combined with a “reset” option. Additionally, this splint simplifies the pretreatment phase by facilitating conservative, surgical, periodontal, and restorative interventions underneath the splint without affecting esthetics or function.¹³ Devices made of highly flexible polycarbonate (b) can be as thin as 0.3 mm, with a very low fracture risk.^{9–11} Finally, the transfer of (b) into the definitive restorations can be proceeded in segments.

Thanks to better restorative materials and adhesive techniques and increased knowledge of how to preserve sound tooth structures, prosthetic dentistry has increasingly turned toward minimally invasive procedures. Bonded all-ceramic veneers and partial crowns offers



FIGURE 1 Maxillary view during the final orthodontic treatment phase with fixed braces on 11, 21, 16, 17, 26, and 27 (FDI). A torque of 10 Nmm was applied to improve the axis of the central incisors. Persistence of primary teeth 55, 54, 53, 63, 64, and 65 (FDI) before prosthetic rehabilitation

benefits in terms of preparation and hard-tissue preservation, from 0% for non-prep restorations to 30% for veneers and partial crowns or even 70% for full crowns.^{14–17} Endodontic problems in the post-prosthetic phase can also be reduced by minimally invasive preparations, and the survival rates of natural abutment teeth can be increased.^{16,18,19}

Restorative materials such as ceramics can be selected based on esthetic and functional requirements. For partial coverage, single-tooth restorations such as onlays and veneers bonded glass-ceramics are the material of choice to accomplish adequate long-term survival rates.¹⁸ However, where all-ceramic resin-bonded fixed dental prostheses (RBFDPs) are indicated as minimally invasive treatment options for anterior teeth, zirconia is preferred as a framework material.^{20,21}

This clinical report documents a full-arch rehabilitation of an agenesis patient with multiple aplasia and primary teeth persisting in the maxilla. The patient was pretreated with a CAD/CAM tooth-colored polycarbonate splint based on the wax-up to explore esthetics, phonetics, function, as well as the new defined VDO. After a pretreatment period of 3 months, the patient was transitioned to definitive all-ceramic restorations using two zirconia based single-wing RBFDPs to replace the missing laterals, two feldspathic veneers to establish the correct proportions on the centrals, and eight non-invasive posterior lithium disilicate (LS₂) occlusal veneers for a stable static occlusion.

2 | CASE PRESENTATION

In 2015, a 16-year-old male patient presented at the Department of Prosthodontics for detailed prosthetic planning related to his ongoing orthodontic treatment. The patient suffered from esthetic and functional impairments due to multiple aplasia of all permanent upper premolars, both canines and both lateral central incisors combined with the associated persistent primary teeth (Figure 1). The cause of these dental anomalies could not be assessed.

Both upper central incisors appeared elongated, and the patient had a massive vertical overbite of 9 mm, combined with an insufficient VDO and maxillary growth deficits. These deficits were clearly recognizable on the diagnostic casts, photographic evaluations, and lateral radiographs (Figure 2). Over the course of the orthodontic rehabilitation, the patient had first been supplied with an activator, then with a twin-block appliance as a functional orthodontic device for mandibular protrusion, and finally with fixed braces. The orthodontic compensation



FIGURE 2 Preprosthetic lateral radiographs combined with orthodontic analysis: SNA, 80.9°; NL-NSL, 11.8°; NSBa, 132.0°; ML-NSL, 17.9°; ML-NL, 6.2°; SNB, 78.2°

achieved in this special situation was limited. The final orthodontic evaluations with the cephalometric values are presented in Table 1.

Consequently, the orthodontic preoperative diagnosis included a distinct skeletal deep bite (covered bite) with a skeletal class II and an Angle class II/2. Both dental arches had a small tendency in the transversal plane.

A thorough clinical examination, intraoral/extraoral photo documentation (Figures 1 and 3), and the necessary radiographic evaluations (Figures 2 and 4) were performed during the first visit to the Department of Prosthodontics. Diagnostic casts were fabricated for mounting in a semi-adjustable articulator (Artex CR articulator; Amann Girrbach AG, Pforzheim, Germany) for further precision planning with a bite record in centric relation and an arbitrary facebow record (SAM; Präzisionstechnik GmbH, Gauting, Germany). Because of the patient's low age, the dental team – in consultation and accordance with the patient and his parents – decided to provide minimally invasive restorations to rehabilitate the maxillary deficits. A tooth-colored splint for the esthetic and functional preprosthetic evaluation and non-invasive single-tooth lithium disilicate (LS₂) restorations (IPS e.max Press Multi A2, Ivoclar Vivadent, Schaan, Liechtenstein; recommended minimum thickness: 1 mm occlusal and 0.3 mm cervically for thin veneers) for the posterior region (upper right canine to upper right second molar and upper left canine to upper left second molar) as well as hand-layered feldspathic veneers (CC, Willi Geller Creation, Meiningen, Austria) for both upper

central incisors were selected as final rehabilitations. The minimum cervical thickness fell short of manufacturer's recommendation due to feather-edge (non-prep) preparations to preserve tooth structure. This is critically discussed in the discussion part.

The two missing upper lateral incisors were replaced by two zirconia-based RBFDPs (Lava Plus; 3M, Seefeld, Germany) bonded to the palatal side of the upper central incisors (CT-CT; Willi Geller Creation).

The material was selected to match the patient's specific esthetic and functional needs. LS₂ (IPS e.max Press Multi A2, Ivoclar Vivadent) ceramics offer high strength and stability for mastication and a favorable esthetic appearance. The RBFDPs also combines the mechanical strength of a zirconia framework with the esthetics of veneering ceramics. For the RBFDPs, minimally invasive palatal preparations accommodated the minimum thickness (0.5 mm for zirconia), a prerequisite for this type of restoration.²¹ In addition, thin non-invasive feldspathic veneer restorations were chosen for their tooth-like optical properties that captured the opacity and translucency of the natural central incisors. The replacement of the missing laterals with dental implants was not included as a treatment option because of the risk of an ongoing vertical dentoalveolar growth in the young patient.^{22,23}

The first treatment step included a preliminary wax-up of the maxilla for an esthetic and functional evaluation. This initial wax-up was fabricated to the height determined intraorally using two posterior templates made of light-curing resin. These resin templates were fabricated in advance on the mandibular cast in the dental laboratory during speech exercises with the patient to obtain an idea of the possible VDO. The subsequent intraoral mock-up (Luxatemp Star; DMG, Hamburg, Germany) was an important tool for the communication between dentist, patient, parents, and dental technician in defining the treatment goal.

The initial wax-up was modified until all parties were satisfied. The first mock-up try-in, for instance, was identified as being too high for an optimal esthetic appearance and facial profile.²² After multiple modifications, the optimized wax-up and the preoperative maxillary and mandibular master casts were scanned with a S600 ARTI scanner (Zirkonzahn, Gais, Italy) for the fabrication of a maxillary tooth-colored

TABLE 1 Final cephalometric values

Cephalometric angle	Measured value	Normal range
SNA	80.9°	80.7° ± 3.4°
NL-NSL	11.8°	7.3° ± 3.5°
NSBa	132.0°	130.0° ± 6.0°
ML-NSL	17.9°	33.2° ± 5.1°
ML-NL	6.2°	25.9° ± 4.9°
SNB	78.2°	77.3° ± 3.1°

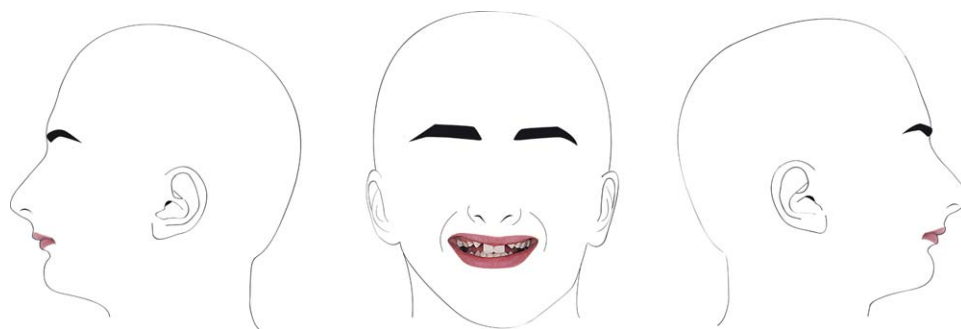


FIGURE 3 Preoperative lateral and frontal schematic profile views

splint.⁸ In designing the tooth-colored splint (by CAD), the correct insertion angle, fitting parameters, and all tooth morphologies were designed according to the tooth database and aligned with the wax-up data.

The maxillary polycarbonate splint (Temp Premium Flexible; Zir-konzahn; recommended minimum thickness: 0.3 mm) was milled with a CNC milling machine (M5; Zirkonzahn), then polished and adjusted in the dental laboratory (Figure 5). The static and dynamic occlusion was verified on the corresponding articulators. After delivery of the tooth-colored splint (Figures 6 and 7), the patient requested a modification because of the more voluminous appearance of the splint. This was performed in multiple steps at the dental laboratory and resulted in exemplary patient compliance (Figures 8 and 9). The dimensional increase manifested itself as a change in the facial profile angle from 155 degrees to 157 degrees and a change of the upper-to-lower proportion from 58% (upper facial height) and 42% (lower facial height) to 53% and 47% (Figure 10).^{24,25}

Preprosthetic function and esthetics were uneventful during the three months before the definitive restorative phase. After this successful "test drive" of the prototype, minimally invasive palatal tooth preparations were performed only for the two wings of the zirconia-based RBFDPs, on the palatal aspect of the central incisors (0.5 mm of enamel reduction). All other teeth remained unprepared. Before taking an impression, retraction cords (size 000; Ultrapak, MS Dental AG, Busswil, Switzerland) were placed to create a more accurate and well-defined cervical emergence profile during the fabrication of the non-prep veneers. Based on the full-arch impressions (Impregum Penta; 3M), the single-tooth LS₂ restorations (IPS e.max Press Multi A2, Ivoclar Vivadent), the two manually layered feldspathic veneers (CC; Willi

Geller Creation) and the two single-wing zirconia-based RBFDPs were fabricated at the laboratory (Figure 11).

Before the try-in, two primary teeth needed a slight enamel reduction on the buccodistal aspect close to the tooth equator, following directives by the dental technician because of minimal undercuts. With this backward planning, the preparation could be minimally invasive. All other primary-tooth morphologies permitted completely non-invasive restorations. The definitive restorations were evaluated intraorally with glycerin gel (Variolink Esthetic Try-in; Ivoclar Vivadent). Insertion of all restorations was simplified by a positioning aid for correct placement (Figures 12 and 13).

A



B



FIGURE 5 Tooth-colored maxillary CAD/CAM polycarbonate splint (occlusal and basal views)



FIGURE 4 Preprosthetic panoramic radiograph with primary tooth persistence in canine and premolar area



FIGURE 6 Frontal view of the inserted maxillary tooth-colored CAD/CAM polycarbonate splint (first version) for evaluating and defining the esthetic and functional goals

After the try-in, the restorations were cleaned in an ultrasonic bath with distilled water for one minute. All final LS₂ single-tooth restorations and feldspathic veneers were adhesively bonded with Variolink Esthetic LC (Ivoclar Vivadent) and pretreated with hydrofluoric acid (HF 5%; LS₂, 20 seconds; feldspathic veneers, 90 seconds) followed by a silane coupling agent containing primer (Monobond Plus; Ivoclar Vivadent). The inner surfaces of the zirconia based RBFDPs were sili-coated (33- μ m grain size) at a pressure of 1 bar (Rocatec soft; 3M) and finally treated with Monobond Plus (Ivoclar Vivadent) for an

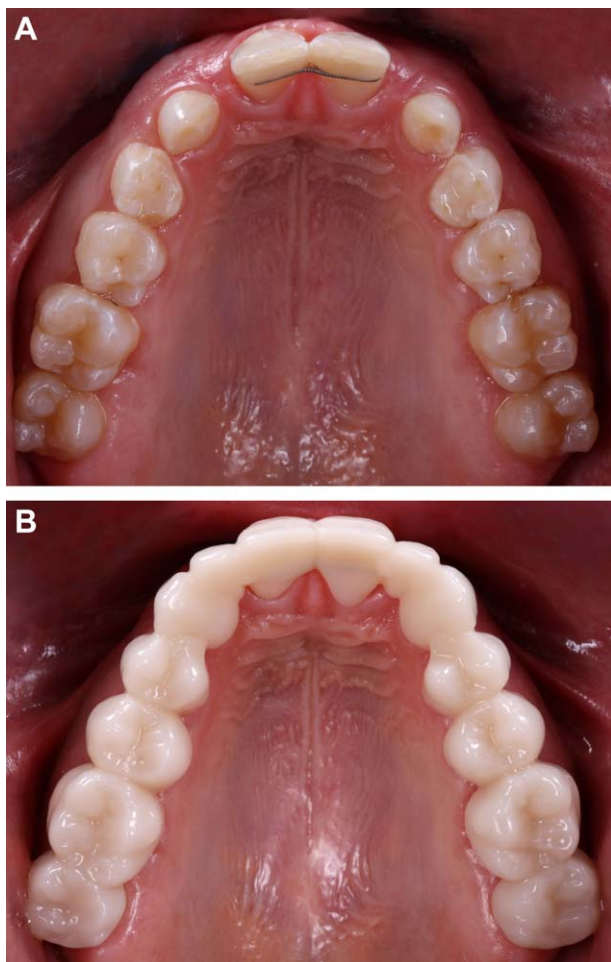


FIGURE 7 Preoperative occlusal view of the maxilla and the clinical situation after insertion of the removable tooth-colored CAD/CAM polycarbonate splint



FIGURE 8 The tooth-colored CAD/CAM polycarbonate splint was modified to meet the patient's esthetic demands for the final treatment goal. This modified splint was tested for 3 months as a prototype of the final restoration with excellent patient compliance

evaporation time of 60 seconds. The teeth were conditioned with a multistep dentin adhesive (Syntac Classic; Ivoclar Vivadent) using the total-etch & rinse technique. The enamel of the deciduous teeth was etched for 60 seconds in total, compared to 30 seconds for the permanent teeth. All restorations for primary teeth were connected by secondarily splinting with a Twistflex retainer, a twisted steel wire that still allowed a certain amount of physiological tooth mobility. For the bonding of the Twistflex retainer, the dental technician had prepared slots in advance into the palatal surfaces of the single-tooth LS₂ Press Multi restorations (Figures 11b and 12). The slots were pretreated with an HF etching gel for 20 seconds and coated with a coupling agent Monobond Plus, Ivoclar Vivadent. For the intraoral fixation, a flowable composite (Tetric EvoFlow; A2, Ivoclar Vivadent) was light-cured with a high-intensity polymerization lamp (Bluephase 20i, Ivoclar Vivadent) on all sides for 20 seconds. All these areas then received a final polish.

The treatment had been carefully planned to reduce the time needed and to achieve the best possible esthetic and functional outcome (Figures 14–16).

3 | DISCUSSION

While low in prevalence, dental agenesis, when combined with bone-growth deficits, often makes it difficult to establish adequate esthetics and function by orthodontic means in young patients.^{1,5–7} This becomes evident in respect to the outcomes (parameters) of the orthodontic treatment, which greatly depend on the severity of the agenesis. In complex cases such as the one presented, an interdisciplinary approach of orthodontists and prosthodontists can be advantageous for both sides. With a minimally invasive restorative treatment, the VDO was redefined, the massive overbite reduced, and the tooth morphologies restored to the extent complex situation allowed.

Initially, a higher VDO had been considered as the treatment goal. However, when implemented in the form of light-curing resin templates and tried in, the young patient's speech was severely impaired. Additionally, the intraoral mock-up of the anterior teeth appeared much too long. To avoid a negative effect on the balance of the face, the planned vertical height had to be reduced.

The guidelines for the soft-tissue profile of the VDO given in the literature could not be fully followed.²⁵ This might have been caused by, among others, the maxillary growth deficits identified in the three-dimensional space on the master casts. These challenges to the



FIGURE 9 Lip profiles showing three successive steps of polycarbonate splint modifications to explore the final treatment goal (from left to right)

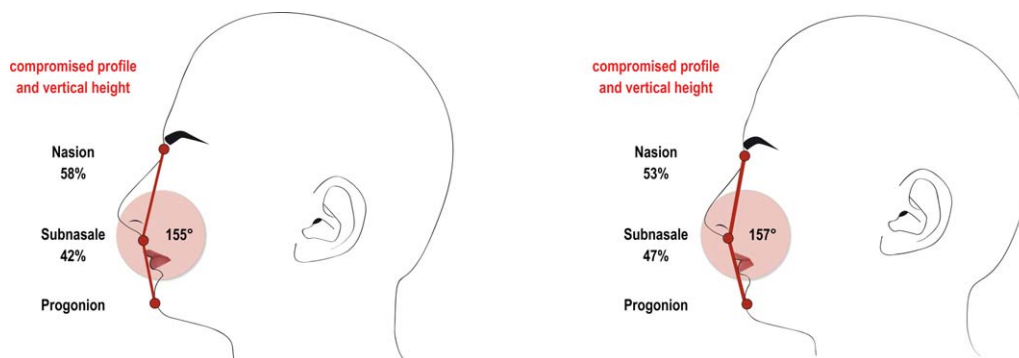


FIGURE 10 Schematic esthetic analysis of the preprosthetic (convex facial profile) and post-prosthetic facial profile for a newly established facial balance and an increase in lower facial height from 42% to 47%

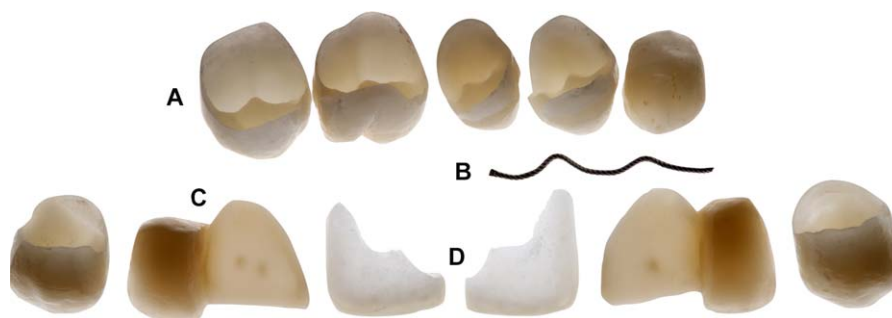


FIGURE 11 Definitive maxillary ceramic restorations. The materials were selected according to the esthetic and functional requirements; A, LS₂ (IPS e.max Press Multi A2; Ivoclar Vivadent); B, Twistflex retainer precontoured for secondary splinting; C, cantilevered zirconia resin-bonded fixed dental prosthesis (RBFDPs); D, additional feldspathic veneers



FIGURE 12 Positioning splint with definitive posterior LS₂ restorations. Small grooves were premolded in the palatal surface for the take-up and intraoral adhesive bonding of the Twistflex retainer. The retainer position is marked



FIGURE 13 Frontal maxillary view with inserted positioning splint for bonding both cantilevered zirconia based resin-bonded fixed dental prosthesis (RBFDPs)

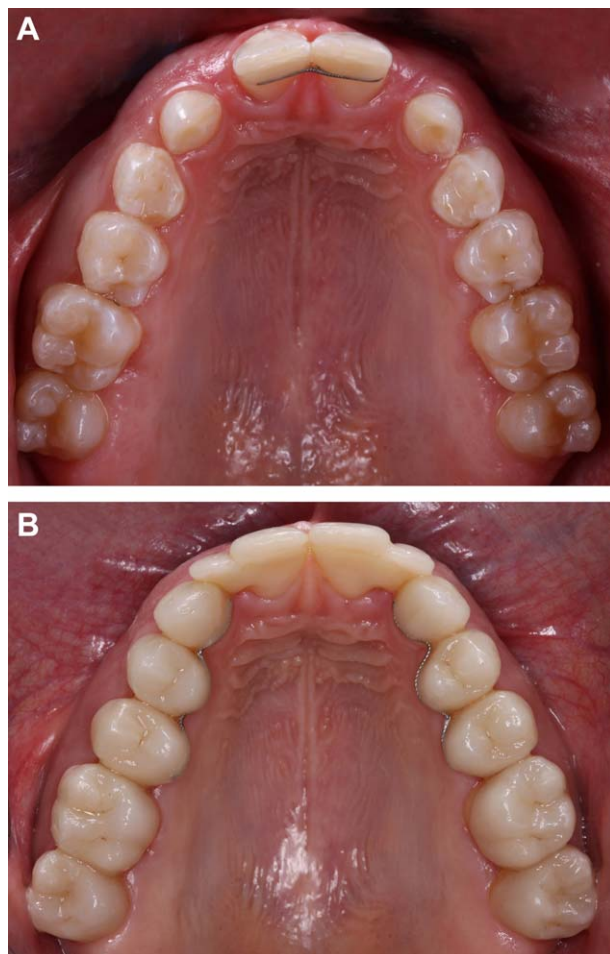


FIGURE 14 Preoperative versus postoperative situation of the maxilla with all bonded all-ceramic restorations in situ

esthetic and functional result were carefully checked in different steps at wax-up and mock-up appointments until all parties were satisfied.

The following comprehensive pretreatment phase with the tooth-colored CAD/CAM fabricated splint increased the predictability for an



FIGURE 15 Preoperative versus postoperative frontal view after insertion of all the all-ceramic restorations



FIGURE 16 Postoperative lip appearance

esthetic and functional acceptable definitive restoration. The appearance of the tooth-colored splint needed to be modified for better acceptance by the young patient and his parents. The problem was seen in the slightly more voluminous splint design compared to the intraorally tested mock-up, which was not fully acceptable. The CAM design of the polycarbonate splint with the data derived from tooth database had resulted in a slightly greater final volume because of the necessary minimum thickness of 0.3 mm and the extension into the undercuts to achieve the “snap-on” effect. The dental technician had to manually reduce the volume and perform some shade modifications, especially in the upper esthetic zone. This pretreatment approach, therefore, was a perfect tool for communication between the patient, his parents, and the dental team for the evaluation of the outcome, beyond the intraoral mock-up,²⁶ and led to excellent patient compliance.

CAD/CAM tooth-colored polycarbonate splints help to immediately visualize the newly defined esthetic and function and anticipate the treatment outcome – even in both jaws if necessary.⁸ It is a non-invasive and removable preprosthetic option for testing the static and dynamic occlusion for up to one year.¹² In the present case, the dental team decided to “test-drive” the occlusion for three months before embarking on the final prosthetic phase. No temporomandibular joint problems manifested themselves during this phase.

The entire treatment presented an enormous challenge for the restorative team because of the deficits in maxillary bone growth with multiple aplasia and primary-tooth persistence. The minimally invasive rehabilitation with additional feldspathic veneers on both upper central incisors, two single-wing zirconia-based RBFDPs, and LS₂ partial-coverage restorations offered benefits in terms of higher survival rates of the natural abutment teeth, combined with a reduced risk for endodontic involvement. The all-ceramic materials were selected to meet the specific requirements of the different indications in terms of esthetics and mechanical properties. During the entire dental treatment, the young patient never received an injection.

For the anterior region, a ceramic build-up technique was used that provided proper opacity, translucency, color, and opalescence. To improve light transmission and a shade gradient in combination with high flexural resistance, the canine and posterior regions were restored with additional LS₂, Ivoclar Vivadent.²⁷

Recommendations in the literature regarding preparation designs for different types of all-ceramic restorations vary significantly. Various geometries have been investigated in vitro and clinically discussed, both for the design of defined margins as well as for feather-edge

designs, mostly related to zirconia ceramics.^{16,28,29} However, the biologically oriented preparation technique (BOPT) using the feather-edge design was considered to be simpler and faster than other techniques (chamfers, shoulders, etc.). Nevertheless, further multicenter clinical studies will be necessary to confirm these preliminary results.²⁸

To the best of our knowledge, there is only very limited clinical evidence regarding the long-term clinical consequences of the variation of the manufacturer's recommendations, beyond beside in vitro studies, case presentations and the introduction of new concepts.^{30–34} This includes the application of anterior feldspathic ceramic veneers without any preparation at all.³⁰ The LS₂ ceramics used in the case presented here had a minimum occlusal thickness of 1 mm and the circumferential areas were fabricated for feather-edge preparation or non-prep situations such as thin veneers (thinly tapered, < 0.3 mm).

Ultra-thin occlusal veneers made of lithium disilicate ceramics are considered a conservative alternative to traditional onlays and full-coverage crowns.^{35,36} In general, the presence of enamel is an important prerequisite for long-term marginal integrity and the biomechanical support of thin restorations.^{37–39}

Cantilevered zirconia-based ceramic RBFDPs represent a promising treatment alternative for anterior single teeth, especially in young patients. A minimally invasive preparation met the prerequisites for this type of restoration. The clinical data available for cantilevered zirconia-based ceramic RBFDPs show promising results.^{20,21,40} In one study, all 42 RBFDPs were still in function (100% survival rate) after an observation period of 61.8 months. During the observation period, however, two cases of debonding occurred, which could be immediately rebonded with Panavia 21 (Kuraray Noritake Dental) as self-curing MDP (10-methacryloyloxydecyl dihydrogen phosphate) containing resin cement.²¹ The inner surfaces of the zirconia-based RBFDPs were air-abraded with alumina particles with no silicoating in the mentioned study.

This procedure – alumina air-abrasion at moderate pressure combined with the use of phosphate monomer-containing primers or luting resins – has been recommended for zirconia restorations based on strong clinical evidence and seems to be associated with less debonding than silicoating (Rocatec soft; 3M).⁴⁰ However, the tribochemical silicoating of the zirconia surface followed by 10-MDP (10-methacryloyloxydecyl dihydrogen phosphate) combined with a silane coupling agent as in Monobond Plus (Ivoclar Vivadent) – as in the present case – has also been highly recommended in the literature.⁴¹ This procedure both roughened the zirconia surface and activated it to make it more receptive for chemical interaction with the silane coupling agent.⁴¹

Despite the known limitations of the zirconia bonding, the inserted RBFDPs have been in situ without failure for 18 months and the bonding seems to be clinically reliable.

Dental implants to replace the missing laterals could have been an alternative, but this option was not considered because of the patient's low age and potentially continuing vertical dentoalveolar growth.^{22,23,42} Alveolar bone growth can be affected by implant placement and should be performed with utmost caution, especially where bone-growth deficits exist.^{22,23} Additionally, based on the oral health-related quality of

life, no significant differences were found between implant-supported single crowns and two-unit cantilevered resin-bonded bridges.⁴³

The minimally invasive approach in the pretreatment and prosthetic phases achieved the best possible esthetic and functional outcome and shortened the treatment time. It was contingent on precise planning and the possibility to easily perform any necessary modifications.

4 | CONCLUSIONS

In complex cases with agenesis of multiple primary and permanent teeth and accompanying anomalies in bone growth, close interdisciplinary cooperation between dentists and the dental technician is essential. With precise preresorative planning, a pretreatment phase as described can increase the predictability and efficiency of the procedure and reduce the overall treatment time. The non-invasive pretreatment with a tooth-colored CAD/CAM splint, combined with the correct selection of different types of all-ceramic restorations, offered an optimal solution for the young patient at very low biological cost.

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