Interdisciplinary Treatment Planning and Digital Workflow Integrating Digital Smile Design and Orthodontic Aligners: A Case Report

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Abstract
An interdisciplinary approach in dentistry is important for comprehensive, complete, and effective patient care because patients are becoming more discriminating, increasing demands for more accurate diagnoses and more detailed treatment plans. The clinical report presented here describes an esthetic rehabilitation using a digital smile design protocol for diagnosis, planning, and execution with a fully digital workflow and performed by an interdisciplinary team. At the first clinical appointment, all examinations, photographs, and videos required for the facially guided smile plan were obtained. With this information, the need for an interdisciplinary team to carry out the rehabilitation, which involved clear orthodontic aligners (Invisalign) as well as periodontal and prosthetic treatment, was verified. The final project planned by the team was forwarded to a digital planning center that transformed the 2D design into 3D and made guides for all stages of the treatment. These procedures and the use of a digital workflow made the treatment more predictable and reliable, and the result of the treatment was directly related to the planning and execution integrating all the specialties involved.

Key Words: computer-aided design, crown lengthening, dental technology, veneers, orthodontics, periodontology, prosthodontics
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Introduction
An interdisciplinary approach must be implemented in dentistry because of the increasing complexity of the skills and knowledge necessary to effectively provide patients with care. This approach is extremely important to ensure a correct diagnosis, expand treatment options, and attain a higher quality of the work. Thus, a team composed of different specialties in which each member contributes their knowledge and skills to solve problems, diagnose patients' conditions, and plan and execute therapies must be organized.

Highly organized communication among team members is necessary for all aspects to be equally expressed and interpreted. Technological resources such as the digital smile design (DSD) protocol facilitate dialogue among professionals who are members of the team and between professionals and patients so that everyone involved in the treatment follows the same project and has the same ultimate goal.

Facial analysis and facial references are extremely important components of smile design because they guide the rehabilitative treatment. These references must be in accordance with esthetic principles, as they are directly related to better facial harmony. DSD utilizes facial references to guide the dental design. In addition, a comprehensive approach to rehabilitative planning and treatment provides results with higher levels of esthetics and function and thus patient health.

Based on this information, orthodontics is a specialty in dentistry that can contribute to more effective patient treatment. By combining the advantages of digital resources with the advantages of orthodontic aligners such as Invisalign (Align Technology; San Jose, CA), treatment plans can be visualized through ClinCheck software, which predicts the possible movements that the aligners will perform. Thus, a prerestorative orthodontic treatment guided by the smile design will allow simulations of treatment integrated with the face and with dental movements to make dental preparations less invasive and preserve the dental structure.

Through facial and dental analyses, it is possible to combine photos, digital models, and cone beam computed tomography (CBCT) to simulate the final result and carefully observe possible limitations or risk factors by using interdisciplinary planning software integrated into the digital orthodontic, periodontal, and restorative planning.

This case report describes an interdisciplinary treatment plan with a comprehensive approach to esthetic rehabilitation. It demonstrates a facially guided treatment using DSD and clear orthodontic aligners, crown enhancement, and ceramic laminates, all performed within a digital workflow.

Case Report
The patient, a 32-year-old woman in good general health, was referred to a dental clinic specifically for esthetic rehabilitation. She was dissatisfied with a nonesthetic smile, specifically with the size and cant of the teeth and the gingival smile. She requested ceramic veneers. A complete examination was performed, including radiographic, clinical, film, and photographic examinations, and the DSD protocol was performed with initial documentation (Figs 1 & 2).
Analysis & Diagnostics
After examination by all team members and observation of facial references to guide the patient’s new smile design, and taking into consideration the patient’s good periodontal status, the need was identified for an interdisciplinary approach including orthodontic and periodontal (crown lengthening) treatment and prosthetic rehabilitation. As part of the treatment, orthognathic surgery was also proposed to the patient; however, she did not consent to this or to having conventional orthodontic treatment performed, which led to the team changing the plan.

Communication
DSD was then performed in 2D for treatment predictability and for better communication among the team members and the patient. The smile design project was sent to the planning center (DSD Planning Center; Madrid, Spain). With the help of NemoSmile Design software (Nemotec; Madrid, Spain), a virtual wax-up guided by the 2D drawing was performed on the 3D digital model (Figs 3a & 3b), and the functional analysis of overbite was made in the virtual articulator within the software. This STL file was printed with a 3D printer (Form 2, Formlabs; Somerville, MA). For this model, a silicone barrier was fabricated for making a motivational mock-up with bis-acrylic resin to present to the patient for her final approval (Figs 4a & 4b).
Diagnosis
The patient was diagnosed with the need for orthodontic movements to be performed using clear orthodontic aligners (Invisalign), crown lengthening, and veneer restorations. A mock-up presentation was prepared for several analyses, such as for whether the occlusion would interfere with the trajectory of the anterior guide. The mock-up was presented to the patient, and she was given explanations about all the planning and all the necessary observations regarding possible difficulties, such as some orthodontic movements, misalignment of the upper and lower midlines, possible occurrence of ankylosed teeth, and third molar extractions, as well as treatment time, sequence, and value. After all the analyses and the conversation, the patient accepted the treatment plan.

Treatment

Orthodontics
Thus, rehabilitation began with orthodontic treatment (Figs 5a-5c). The DSD project for orthodontic movement guided by the smile design was carried out through collaboration between ClinCheck software and NemoSmile Design. A total of 22 aligners were used to complete the orthodontic treatment. The purpose of the treatment was to expand the arches and align the teeth with consideration to the final restorations. Then, a minimally invasive preparation would be performed to receive the veneers. To accelerate the orthodontic movement and reduce the treatment time, a technique introduced by Murphy in 2006 was performed. The micro-osteoperforation procedure (Excellerator RT, Propel Orthodontics; Milpitas, CA), which consists of bone perforations, was performed. The purpose of this type of procedure was to induce inflammatory markers such as chemokines and cytokines, which are responsible for osteoclast recruitment, bone remodulation, and osteoclast maturation in the area. Thus, the procedure allowed the patient to change aligners every three days. On conclusion of the orthodontic treatment, digital quality control was performed to evaluate whether the aligner treatment objectives had been reached. This was done by superimposing the images from the initial file onto the postorthodontic treatment file with ClinCheck.

Periodontal Procedures
After orthodontic treatment, considering that the patient had good periodontal status with a maximum probing depth of 3 mm and no bleeding on probing, the periodontal treatment began. For crown lengthening, the planning center used the perio analysis tool of the NemoSmile Design software. The CBCT image was superimposed onto the STL file of the virtual wax-up model; thus, it was possible to define the ideal gingival level
because the wax-up was based on the facially guided digital design. The bone level was defined from the future gingival level for the purpose of maintaining the biological space; thus, a digital guide for the dual technique was created for use during surgery. This guide provided references for the gingival (bottom of the guide) and bone (top of the guide) levels and thus provided an acceptable reference for maintaining the biological space (Figs 6a-6f). The guide was printed with a 3D printer (Form 2), making the surgery more predictable. Gingivectomy and bone reduction for crown lengthening were performed. Even with the increase in the clinical crown length, the patient still presented a gingival smile, as foreseen in esthetic planning. The patient was presented with the possibility of using botulinum toxin (Botox, Allergan; Dublin, Ireland) to paralyze the muscles; however, the results of this treatment last for a maximum of six months, and the patient would need to have applications at least two times per year to maintain the results. The patient agreed to this treatment, and a controlled quantity was then used to minimize the mobility of the upper lip elevator muscles, consequently minimizing gingival exposure in the broad smile.20

"To accelerate the orthodontic movement and reduce the treatment time,16,17 a technique introduced by Murphy18 in 2006 was performed."

Figures 5a-5c: Planning the result of orthodontic treatment with clear aligners via facially guided alignment and verifying with software. Patient placing the aligner in position. Intraoral view after orthodontic treatment.
Restorative Steps

After the 90-day period of gingival stabilization after surgery,21 restorative treatment began. For precise and predictable execution, the planning center forwarded the motivational mock-up STL file and two other STL files for two different situations. One of these two files guided the dental preparations, called the ideal pretreatment STL, and the other guided the final rehabilitation, called the ideal posttreatment or technical STL, which could be used for the provisional and the final prostheses. Thus, a model was printed, and a silicone index was made from the ideal pretreatment STL. A mock-up was made of bis-acrylic resin to guide the dental wear. Thus, a minimally invasive preparation that preserved tooth enamel was performed (Figs 7a-7d).22

After this, a digital scan (iTERO, Align Technology) of the preparations was performed. The ideal posttreatment STL was superimposed onto the STL of the preparations to guide the CAD production of the laminated veneers (Zirkonzahn; Gais, Italy). Lithium disilicate HT BL1 blocks (IPS e.max CAD, Ivoclar Vivadent; Schaan, Liechtenstein) were milled on the Zirkonzahn M1 wet milling machine (Zirkonzahn). The parts and the teeth were prepared in accordance with the manufacturer’s instructions, and cementation was performed with RelyX Veneer cement B ½ (3M ESPE; St. Paul, MN), controlling the moisture and avoiding contamination. The occlusion was evaluated, excess cement was removed, and polishing was performed.

The case was completed, and the patient was satisfied with the result (Figs 8a & 8b). The patient received necessary postoperative instructions, and follow-up assessments were made the following week, the following month, and then at least once a year.

Discussion

Digital Technology

The implementation of digital technology is advancing in dentistry. The conventional workflow has been replaced by the digital workflow because the latter is more efficient.12,13 In addition, computers and a digital workflow make jobs easier, faster, cheaper, and more predictable.11,13

Following the digital workflow concept, a DSD protocol was used to guide the plan digitally, integrating all facets of the treatment. Subsequently, the project was forwarded to a digital planning center (DSD Planning Center) to ensure accuracy and equivalence between planning and execution. Thus, the planning center transformed the 2D project created by the dentist using his software or app into a 3D format and created guides for the prosthetic, periodontal, and orthodontic treatments. Thus, all the necessary procedures throughout the treatment could be predictable.
Integrated Plan

The need for greater harmony and better dental aesthetics in periodontal procedures commonly arises in esthetic rehabilitation. The use of digital resources and planning guided by facial references and smile design were key factors in achieving this goal. The use of a double technique for crown lengthening allowed references for gingival and bone reduction during surgery, and this technique was able to reduce errors and create predictable gingival and alveolar margins.

In contrast to using only orthodontic aligners, in which the treatment is oriented only by the teeth in the arch, the integration of a DSD-Invisalign protocol allowed the orthodontist, by means of ClinCheck, to visualize the rehabilitator’s esthetic planning in harmony with the patient’s face. Thus, he was able to perform dental movements into ideal positions that resulted in minimally invasive preparations.

With the defined plan, a motivational mock-up could be performed to simulate the entire treatment outcome, which the patient could consider during the planning stage. This integration made it possible to predict the final result even before starting treatment. The two major technical impacts of DSD on orthodontic alignment were face-oriented orthodontic planning and interdisciplinary integration in planning. In this case, the aligners were able to safely correct the dental arches and perform movements equivalent to those that were planned. As a limitation, however, the patient had two deciduous teeth (#A and #K) that did not adequately respond to the orthodontic movement because they were ankylosed.

The entire treatment was based on DSD performed through facial analysis. Combining the technologies of DSD and ClinCheck, the orthodontic movements were performed with consideration to what the result of the treatment would be. This protocol was more predictable and led to a less invasive preparation for receiving veneers. Furthermore, using the STL model from the DSD and merging it with the DICOM file from the CBCT, it was possible to predict the crown lengthening so that the final restorations would not invade the biological space. Without these technologies, the treatment would not have been as predictable. In addition, the technologies allowed the dentists to feel more confident while performing the treatment because of the correct planning and all the guides it provided.

The favorable outcome of this treatment was directly related to the planning and execution that integrated all the specialties involved. In addition, the digital workflow was responsible for treatment predictability and accuracy.
Summary
This case report described an interdisciplinary approach using orthodontic, periodontal, and prosthetic treatment for an aesthetic rehabilitation using a digital workflow. Through a fully digital, interdisciplinary, and facially guided plan integrating DSD and orthodontic aligners, it was possible to predictably obtain a final result equivalent to the planned one.

References


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1. What is the main advantage of using a digital smile design (DSD) protocol?
   a. Improved communication among the professional(s) involved in the treatment and the patient.
   b. Less need for radiographs during treatment.
   c. Decreased cost for the patient.
   d. Minimized need to include other dental specialists in the treatment.

2. DSD uses which of the following to guide the dental design?
   a. Study models mounted in centric relation.
   b. Radiographs combined with a full periodontal evaluation.
   c. Facial references.
   d. Evaluation of the bite and golden proportion of the anterior teeth.

3. ClinCheck software allows a dentist to predict which of the following?
   a. The magnitude of occlusal forces during chewing.
   b. Possible movement of the teeth with Invisalign aligners.
   c. The amount of preparation needed for successful restorations.
   d. The benefits of opening the bite through posterior tooth movement.

4. What is micro-osteoperforation?
   a. A sandblasting technique used during crown lengthening to soften the bone.
   b. Numerous small perforations that allow bone growth factors to be applied to thicken the bone.
   c. Bone perforations that induce inflammatory markers responsible for faster bone remodeling.
   d. When the alveolar bone is roughened during crown lengthening to improve the amount of attached tissue.

5. In the case presented, why was micro-osteoperforation completed?
   a. To improve blood flow for healthier gingival tissues after crown lengthening.
   b. To accelerate the orthodontic movement and reduce the treatment time.
   c. To thin the bone in the areas of crown lengthening.
   d. To avoid the need for crown lengthening.

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