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Direct printed removable appliances: A new approach for the Twin-block appliance

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Removable appliances are an important part of orthodontic treatment. The Twin-block is widely used for Class II correction. Traditionally, an impression, bite registration, and mounted plaster casts are required to fabricate the acrylic appliance, which usually requires a specialized laboratory. This makes the process expensive and also time-consuming.

This paper aims to present an innovative approach for the virtual design and direct printing of removable orthodontic appliances, particularly the Twin-block, that can be done in-office without the need for casts or a specialized laboratory. (Am J Orthod Dentofacial Orthop 2022;162:103-7)

Class II malocclusion is one of the most frequently managed malocclusions in orthodontics. It is estimated that between 30%-45% of Caucasian patients present with the Class II pattern.[1] In the majority of those patients, the etiology is a retrognathic mandible[2]; hence, the more popular approach is to use functional appliances aiming to correct the mandibular position.[3] Removable functional appliances are popular in Class II correction, ideally timed around the pubertal growth spurt with many designs published in the literature.[4] The Twin-block introduced by Clark[5] is a popular design used in many previous studies and has the advantage of being composed of an upper and lower plate, thus facilitating function and speech with the appliance, greatly enhancing the ability of the patients to wear the appliance full time. In addition, the design allows for the incorporation of expansion screws springs for tooth movements and good control over the vertical dimension with eruption guidance planes and selective grinding of the acrylic blocks. Retention is usually through metal wrought-wire clasps. Traditionally, removable functional appliances require impressions and bite registration. The models are mounted in the corrected Class I position on an articulator. An acrylic appliance with wire clasps is constructed and cured. This process requires a specialized laboratory, which is time-consuming and expensive.

In recent years, 3-dimensional (3D) printing has revolutionized many aspects of dentistry and appliance manufacturing.[6] From making study models, printed indirect bonding guides to direct printing of metallic appliances.[7] This paper introduces a simple method using an in-office printing procedure to design and manufacture a modified Twin-block appliance directly from 3D intraoral scans on 2 patients. The aim was to produce an orthodontic appliance in a single process with a simple 3D acrylic print without additional wire elements or expansion screws.

MATERIAL AND METHODS

A 3D intraoral scan was obtained using (Trios 2 Pod Version; 3Shape, Copenhagen, Denmark) and then the 3D model was imported into the appliance designer software (3Shape). The models were then virtually articulated into the desired relationship in a Class I molar and canine relationship with sufficient interocclusal space to allow acrylic plates (Fig 1, *A*). The 3Shape scanning software allows for a virtual bite registration record to be obtained however manual repositioning of the models on the virtual articulator is also possible.

The software is then used to virtually create the desired framework with extensions over the occlusal surfaces of the teeth providing a similar overall surface to a

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classic removable appliance with an acrylic base (Figs 1 and 2). The surface of the shell against the jaw surface was set at a relief distance of 0.1 mm from the tissue. The thickness of the acrylic shell was set at 2 mm but was increased in specific areas to contribute to greater retention and stability-enhancing resistance to potential fracture.

Retention for any removable appliance is essential, and traditionally wrought-wire clasps are used. However, the aim was to eliminate the need for metallic clasps as they would have to be bent and placed separately, and our objective was to produce an appliance that could be directly printed with minimal requirement for postprint processing. The easiest way to produce predictable retention without using Adam's, C- or other wire clasps was to use the natural dental undercuts with acrylic base by planning a path of insertion similar to what is done with partial dentures. The software makes it possible to block or use undercuts, similar to when surveying undercuts for retention of partial dentures in prosthodontics. The retentive hold of the appliance was planned in the way of a regular bruxism splint (Michigan-splint) with undercuts engaging the maximum convexity of the surfaces of the teeth. A path of insertion was designed and would need to be shown to the patient at appliance fitting. A software combination of orthodontic and prosthodontic software platforms would have made this step easier, as, in prosthodontics, a path of insertion must be planned for bridges and partial dentures, and it is an easy step to find step within the software; however, this is not available in the orthodontic software at this stage. The software allows the creation of either a homogeneous gap between the tooth and gum surface and the appliance or for all undercuts to be blocked out.

The regular extension of the appliance covers the permanent teeth by 2 mm over the gingival border (Figs 1 and 2). In the case of deciduous teeth, space can be left to allow for their shedding and guided eruption of the permanent successors. Vertical control can be factored in using the guidance planes and then by selective grinding of the appliance during treatment. Other elements such as expansion screws, finger-springs, and labial bow, and so on can be planned for insertion in the acrylic base after printing; however, this was not done in these patients.

In the presented patients, the maxillary removable appliance was designed to facilitate correction of the traumatic anterior deepbite through the passive eruption of the mandibular premolar and molar teeth, with a concomitant increase in the occlusal vertical dimension. The shell was produced with a thicker part anteriorly resembling a bow from canine to canine (Fig 2).

Alternatively, in a patient with mixed dentition, the maxillary deciduous canine and first deciduous molar should not be covered by the shell, giving space for them to shed.

The extension of the lingual shell in the mandible beyond the protruding block aims to give the mandibular first permanent molar the possibility for a guided eruption (Figs 1 and 2). However, as there is still a need for a stable hold, the shell was thickened and extended on the lingual cervical side of the mandibular molars, just going below the height of contour of the crows, 2-3 mm over the gingival margin, even though this could stop the wanted elongation of the molar in a patient with a deepbite.

The blocks and ramps are virtually performed elements kept in a digital library, so they can be put in the right position on the base shell saving time in the virtual design process. A more obtuse angle to the 70° inclination prescribed in the original Twin-block design was used to reduce the tilting moment dislodging the appliance reducing the demand on the retention components.

The final design is added to the building platform of the stereolithography additive manufacturing) 3D printer (Form2, Formlabs, Netherlands) and printed in Ortho Clear (NextDent, the Netherlands), one of the first biocompatible Class IIa acrylic resins.[8] After the printing process, the build platform with the appliance parts still attached is removed from the printer, leftover resin allowed to drip off, and then the appliance is removed from the building platform. The parts of the Twin-block are then washed with >90% isopropanol alcohol in an ultrasonic cleaner to remove any residual resin. After all the residual resin parts are washed away, the Twin-block is light-cured in a light-curing box to complete the polymerization of the resin. If desired, the other elements, such as expansion screws or clasps, can be added to the planned sockets and fixed with self-curing acrylic resin (Fig 3). All these steps must be performed with the needed precautions to protect the operator from the fumes according to the specific printer guidelines.

In this patient, after polishing the interdental parts, the patient was able to click the appliance in the maxilla and mandible straight over the teeth, and retention was excellent.

The first patient is a male patient aged 10 years with a Class II Division 1 malocclusion on a skeletal Class II base with a deep overbite, increased overjet, and mandibular retrusion (Fig 4). No leveling and aligning were needed in this patient to fit the printed Twin-block on the maxillary incisors. The second patient is a female patient aged 11 years presented with a Class II Division malocclusion with a skeletal Class II pattern deep overbite and

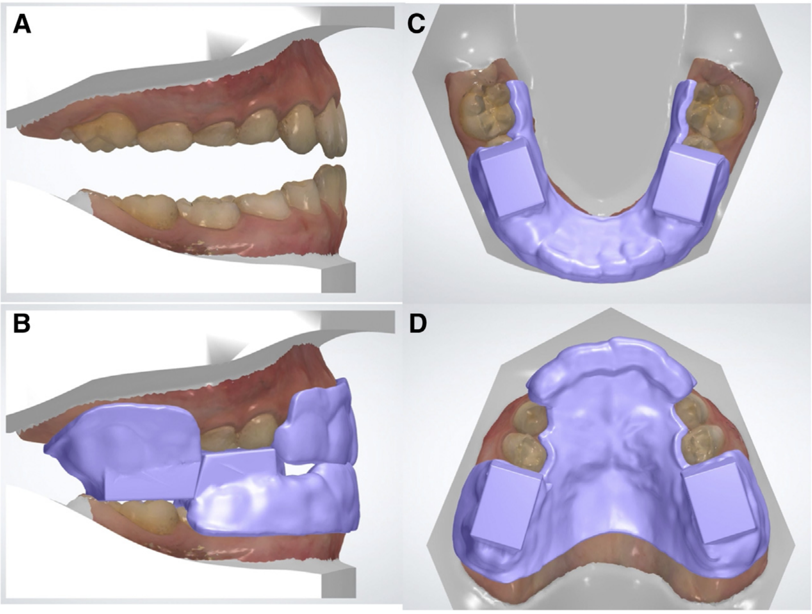

Fig 1. A, Digital positioning of the jaws in Class. **B,** Virtual Twin-block Design on the cast. **C,** Virtual Twin-block design mandible occlusal view. **D,** Virtual Twin-block design maxilla occlusal view.

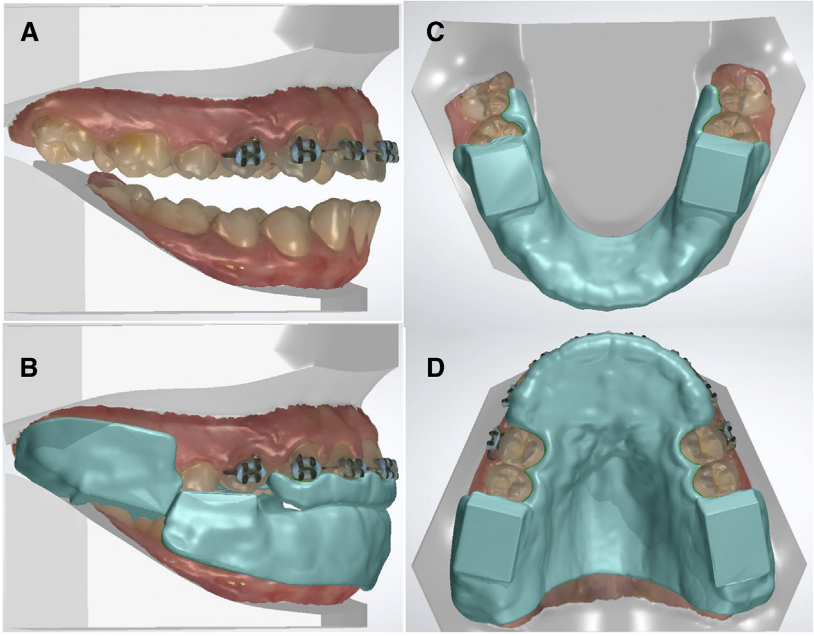

Fig 2. A, Digital positioning of the jaws in Class I. **B,** Virtual Twin-block design on the cast. **C,** Virtual Twin-block design mandible occlusal view. **D,** Virtual Twin-block design maxilla occlusal view.

mandibular retrusion (Fig 5). To facilitate the full correction and advancement of the mandible into a Class I position, the maxillary arch needed to be initially leveled and aligned with fixed appliances to establish the maxillary incisor position then the digital Twin-block was fabricated.

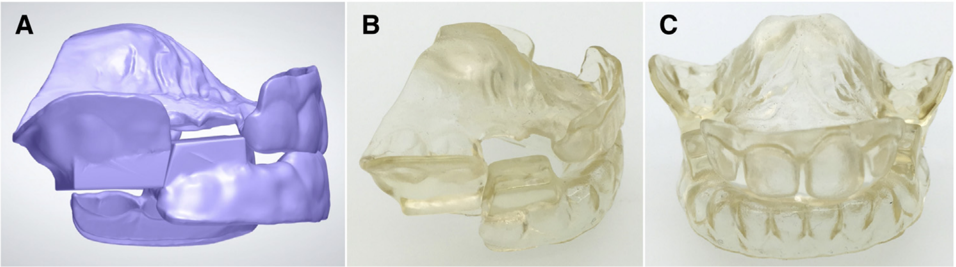

Fig 3. A, Virtual Twin-block design. **B,** 3D-printed Twin-block lateral view. **C,** 3D-printed Twin-block anterior view.

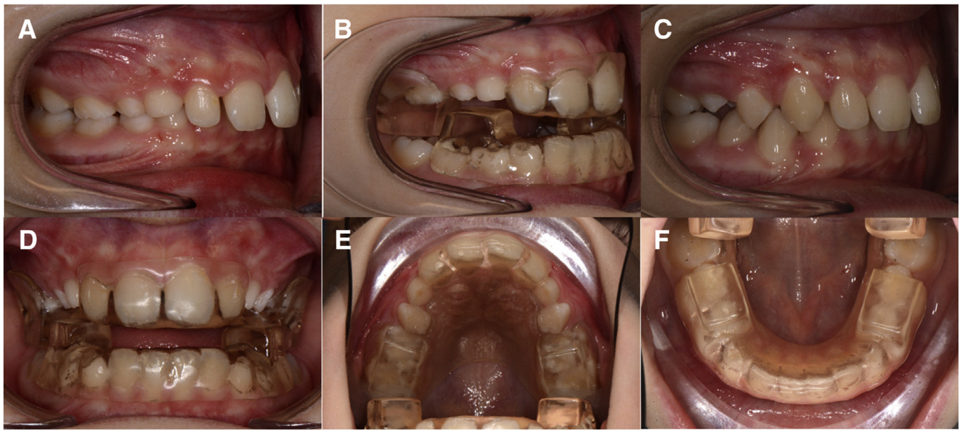

Fig 4. A, Lateral view before Twin-block. **B,** Lateral view during Twin-block therapy. **C,** Lateral view after Twin-block. **D,** Twin-block in situ anterior. **E,** Twin-block in situ maxilla occlusal view. **F,** Twin-block in situ mandible occlusal view.

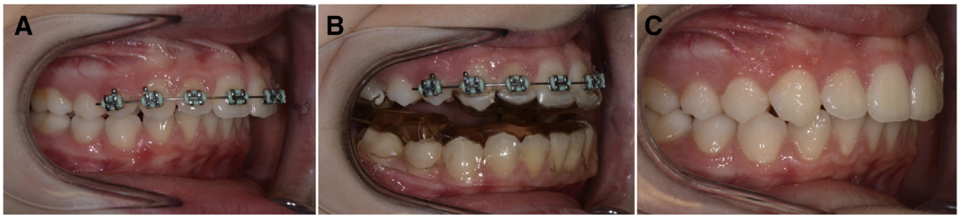

Fig 5. A, Lateral view before Twin-block. **B,** Lateral view during Twin-block therapy. **C,** Lateral view after Twin-block.

DISCUSSION

The above process demonstrates a practical stepwise procedure for the clinician to directly plan and fabricate a removable functional appliance, the Twin-block, in-house and without using any plaster casts. This method is fully digitized without the need for printed models of the arches. There are several advantages to this method over conventionally fabricated appliances. First, scans are similar to traditional impressions in accuracy, but intraoral scanning can be more comfortable and easier to tolerate for many children than conventional impressions.[9] Children can have a break during the scan if necessary without compromising the quality of scans. In addition, by eliminating the variables that may be introduced during mixing the impression material, obtaining the impression, the handling, storage, and pouring up of the impressions, and then handling the plaster casts, possible distortions are eliminated.[9]

This approach can also be considered more environmentally friendly because of the reduced waste. Furthermore, by eliminating the laboratory steps, the appliances can potentially be produced in-house, thus reducing costs and turnaround time for practices and patients, especially with faster printers now becoming available. The choice for biocompatible printable materials is increasing, opening more design possibilities for directly printed appliances.

By using natural dental undercuts to retain the appliance, the need for bending metallic clasps can be reduced or eliminated. However, this is a concept that orthodontists need to become familiar with. A path of insertion and removal needs to be carefully incorporated into the design and then demonstrated to and mastered by the patient, which is a step most practitioners will not be familiar with if they are used to using wrought-wire clasps. Should metal clasps or springs be required in the appliances, the design process can allow for their bedding to be created in the framework to be added and secured with resin after the frame is printed. Software development also allows some of the commonly used appliance components to be digitally preprepared and stored in a virtual library in the design platform to save time producing future appliances. With further software development and artificial intelligence, perhaps appliance design can be somewhat automated, further streamlining the process and reducing the time and effort needed for production.

With the choices of printable materials, increasing the use of more elastic materials may allow active components that can move individual teeth to be incorporated. With further material improvements, the appliances can potentially act as an aligner within a functional appliance allowing for some tooth movement to be programmed. With the reduced cost of production, such devices can then be changed akin to plastic aligners every few weeks or months, depending on the resilience of the material, as the programmed tooth movement expresses itself. In addition, control of the vertical dimension and guided tooth eruption may also be performed by allowing eruption planes to be factored into the framework and selective grinding during treatment. Some software platforms now allow for the anatomy unerupted teeth to be incorporated into the final design using cone-beam computed tomography data, allowing for reasonably accurate eruption guidance.[6]

Although material properties need to be expanded, it is important to consider other material properties such as color. Most removable appliances are used in children, and a choice of fun and attractive colors and patterns must be considered a future requirement for printable materials as it may improve acceptance and compliance with treatment.[10] Digital design can open further possibilities to make designs and color patterns attractive to children, potentially expanding on what is now possible with conventional acrylic resin appliances.

This case presentation introduces a method to directly design and print a removable functional appliance. This method can have many advantages; however, further research and clinical trials would be required to assess the efficacy and success of this method, the longevity of the materials, and the success of the clasp-free retention.

SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ajodo.2021.08.019.

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