CASE REPORT

Prabhat Kumar Chaudhari, Ilser Turkyilmaz, Edlira Zere, Ramandeep Kaur Sokhi

In-house aligners for correction of relapse in mandibular incisor alignment

Prabhat Kumar Chaudhari

KEY WORDS *3D printing, 3D scanning, aligners, incisor crowding, orthodontics, relapse*

Objective: *To describe a technique for fully digital in-house aligner fabrication to treat orthodontic problems encountered during the coronavirus pandemic.*

Case description: *A 21-year-old woman presented to the outpatient department of the Division of Orthodontics and Dentofacial Deformities at the Centre for Dental Education and Research, All India Institute of Medical Sciences in New Delhi, India with the chief complaints of impingement due to a broken mandibular fixed retainer and relapse of mandibular incisor alignment. After resolving the impingement problem, a fully digital in-house aligner was used to correct the misalignment of the mandibular anterior teeth over a treatment period of 2 weeks without any support from an external laboratory.*

Conclusion: *The use of CAD/CAM technology together with 3D printing and thermoforming, as described in the present report, may represent a feasible approach for treating mild orthodontic problems without the need to outsource laboratory support; it is therefore a practical treatment option during the coronavirus pandemic.*

Prabhat Kumar Chaudhari, MDS, MFDS RCPS (Glasg)
Associate Professor, Division of Orthodontics and Dentofacial Deformities, Centre for Dental Education and Research, All India Institute of Medical Sciences, New Delhi, India

Ilser Turkyilmaz, DMD, PhD
Clinical Professor, Department of Prosthodontics, New York University College of Dentistry, New York, NY, USA

Edlira Zere, DMD, PhD
Craniofacial Orthodontist, Department of Orthodontics and Craniofacial Anomalies, Rambam Health Care Campus, Technion – Israel Institute of Technology, Faculty of Medicine, Haifa, Israel

Ramandeep Kaur Sokhi, MDS
Division of Orthodontics and Dentofacial Deformities, Centre for Dental Education and Research, All India Institute of Medical Sciences, New Delhi, India

Correspondence to: Dr Prabhat Kumar Chaudhari, Division of Orthodontics and Dentofacial Deformities, Centre for Dental Education and Research, All India Institute of Medical Sciences, New Delhi, 110029, India.
Email: dr.prabhatkc@gmail.com

Introduction

The coronavirus (COVID-19) pandemic is currently having a direct impact on all social settings and professions, including orthodontics[1]. As the circumstances surrounding the pandemic continue to evolve and the world suffers the consequences, orthodontic offices are resuming their services by taking precautions to reinforce infection prevention and control measures and minimise the number of appointments scheduled for treatment[1].

Maintaining the alignment of the mandibular anterior teeth in the corrected position and preventing them from returning to their initial pretreatment positions is challenging for orthodontists. Despite receiving the best possible care, only 50% of orthodontic patients are able to retain the alignment of their mandibular anterior teeth for the next 10 years[2].

Orthodontic relapse can be managed using fixed or removable appliances. The fixed appliances commonly used to correct relapse are labial braces, lingual braces and flex-

ible wire bonded to the lingual surface of the mandibular anterior teeth after using brackets, and the frequently used removable appliances are the conventional Hawley appliance and clear aligners[2]. Fixed retainers prevent not only relapse but also tertiary crowding[3]. Aligner therapy facilitates the treatment of mandibular anterior crowding (mild spacing or crowding ≤ 4 mm) or relapse that occurs during the retention phase. Clear aligners are an aesthetic, efficient and comfortable appliance but require meticulous digital planning and clinical and laboratory procedures[4]. There are two types of clear aligners: analogue and digital. Analogue aligners are vacuum formed on the conventional physical stone cast and the teeth are reset. Fabrication of digital clear aligners begins with acquisition of a digital 3D model of the dental arch either by direct or indirect 3D scanning, the former using an intraoral scanner and the latter using desktop scanners, of the dental impression or stone cast. All the desired tooth movements are manipulated digitally and a series of models of the different treatment stages are 3D printed for thermoforming of aligners[4].

Currently, the most common application of 3D printing in orthodontics is in the commercial production of digital aligners to correct misaligned teeth[5]. First, digital models of the maxilla and mandible are acquired through intraoral or desktop scanning. Second, specifically designed computer-aided design (CAD) software is used to perform the digital tooth movement with the aim of placing the teeth in the desired position. Third, patient-specific digital models are created for various treatment stages in standard tessellation language (STL) file format. This is the most extensively used file format for 3D printing[4,5]. It encodes the surface geometry of a 3D object into a tessellated triangular mesh, a pattern consisting of small, non-overlapping adjoining triangles. Fourth, a 3D printer is used to produce rapid prototypes of these STL files of dental models for different treatment stages. Finally, orthodontic aligners are fabricated on these 3D printed dental models by thermoforming using thermoplastic sheets[6,7].

State-of-the-art clinical experience and high-quality evidence have shown that clear aligners are able to treat mild to moderate malocclusion with acceptable clinical outcomes comparable to those obtained with fixed appliances[8-10]. Furthermore, in the midst of the COVID-19 pandemic, aligner therapy offers the advantage of reducing the number of follow-up visits, which translates into fewer orthodontist–patient–parent encounters and may therefore help to prevent the spread of the virus and reduce the requirements for personal protective equipment (PPE). As a result, orthodontists could consider using aligners to treat mild to moderate malocclusion[11].

Thermoplastic clear aligners have attracted great attention from dental professionals and patients[12]; however, the main disadvantages of the Invisalign system (Align Technology, San Jose, CA, USA) and other similar systems are the dependency of orthodontists on laboratory support provided by these companies and the increased laboratory cost. The provision of in-house laboratory support would enable orthodontists to plan and deliver clear aligners for minor tooth movements.

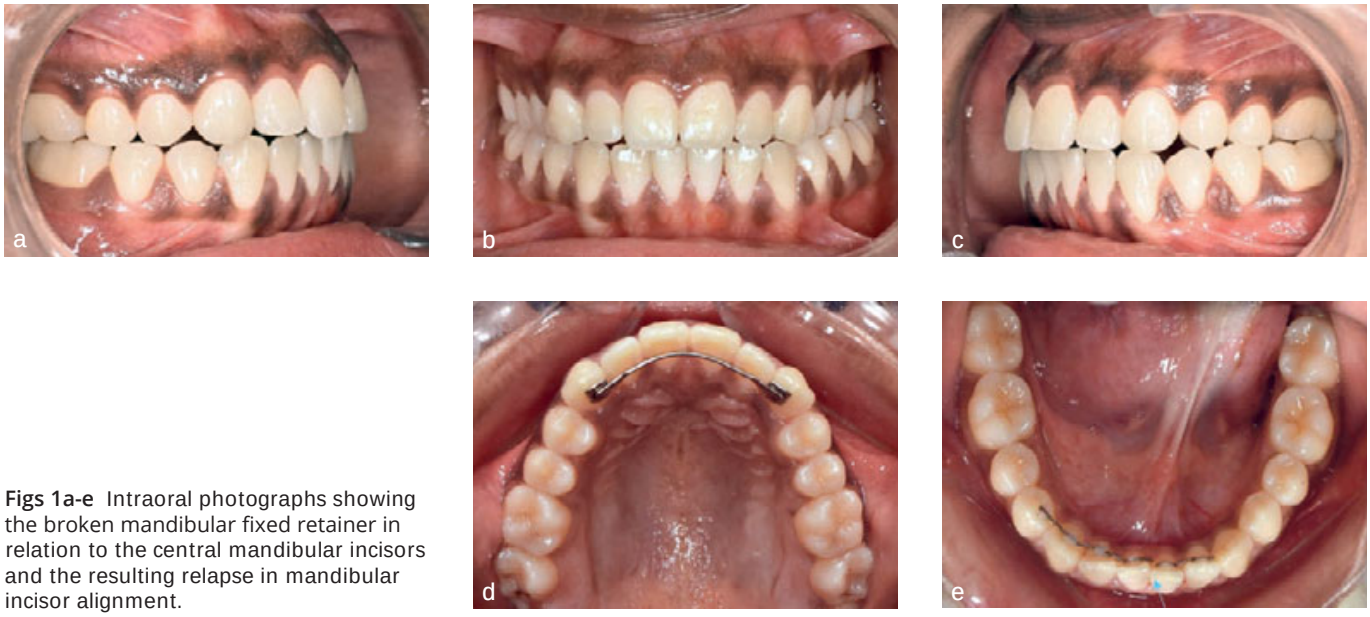
The present clinical report illustrates the application of in-house digital clear aligner therapy to correct mandibular incisor crowding and misalignment due to orthodontic relapse during the COVID-19 pandemic.

Case presentation

A 21-year-old woman called the Orthodontic Outpatient Department of the All India Institute of Medical Sciences, New Delhi, India, on the patient teleconsultation number introduced during the COVID-19 crisis with the chief complaints of impingement due to a broken mandibular fixed retainer and relapse in the alignment of the mandibular anterior teeth. As she had no COVID-19 history or symptoms, the patient was scheduled for an in-person visit. The broken fixed retainer was cut and adjusted using the appropriate PPE. Because the patient was concerned about the relapse of mandibular anterior alignment, a plan was made to align the mandibular anterior teeth using aligner therapy.

The patient stated that she had undergone nonextraction fixed orthodontic treatment and had been following a retention protocol for the previous 3 years; however, the pandemic situation meant that she had not been able to attend follow-up visits in the past 6 months. On clinical examination, the mandibular fixed retainer was found to be broken between the mandibular central incisors, while the maxillary fixed retainer was intact (Fig 1).

The broken retainer had caused relapse of the mandibular incisor alignment. The broken lingual fixed retainer was



Figs 1a-e Intraoral photographs showing the broken mandibular fixed retainer in relation to the central mandibular incisors and the resulting relapse in mandibular incisor alignment.

cut and adjusted to provide relief from the impingement. On clinical examination, the mandibular left central and lateral incisors and right lateral incisors showed mesiopalatal rotation and the right central incisor was labially positioned. The options to correct the relapse of mandibular incisor alignment using either fixed appliances or aligners were explained to the patient and her mother. After discussing the advantages and disadvantages of both appliances and the precautions required for follow-up during the COVID-19 pandemic, a joint decision was made to use aligner therapy to correct the relapse. Due to the pandemic situation, certain modifications were made to the digital plan and the complete in-house laboratory workflow to fabricate the aligners, which made the present case unique when compared to a previously published report using commercially available clear aligners[13].

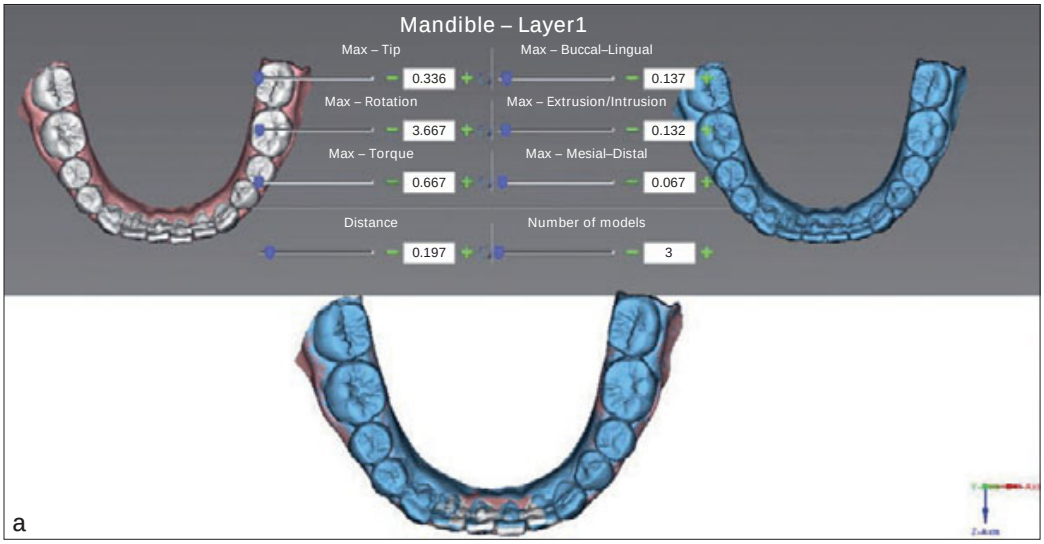
Treatment

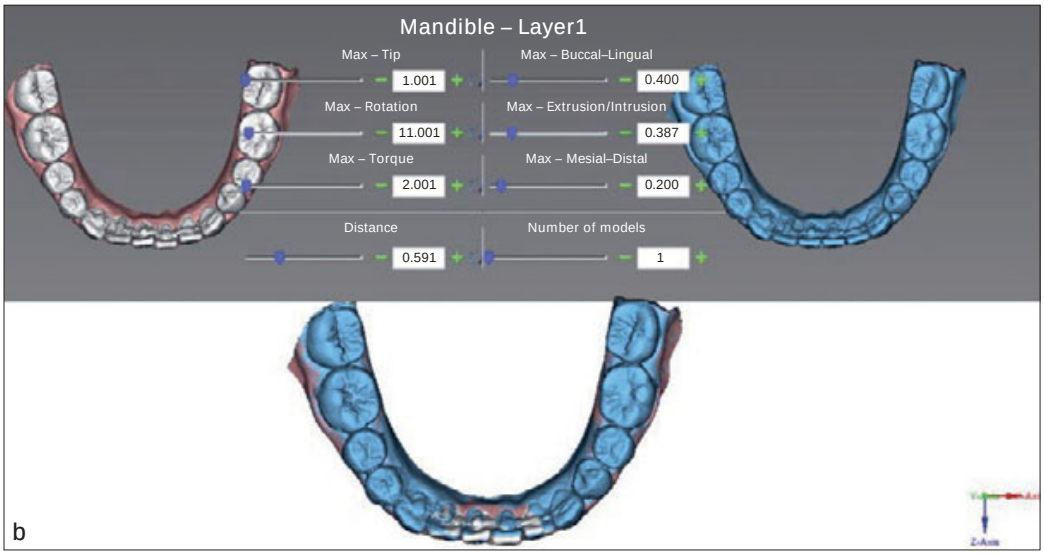
Day 1

As per protocol, patients were required to wear a mask at all times when in the clinical area of the department except during treatment, as a preventive measure to limit the spread of COVID-19. The Indian government had classified the clinical area of the dental operatory as "moderate risk" and recommended use of PPE (N95 masks, goggles, latex examination gloves and face shields during aerosol-generating procedures) during clinical procedures. The patient was asked about her COVID-19 history and whether she was displaying any symptoms. She was also asked to rinse with povidone-iodine (0.23%) mouthrinse for 15 to 30 seconds prior to the clinical examination. The dental chair was sanitised after each patient using freshly prepared sodium hypochlorite solution. The doors of the postgraduate operatory were kept closed, with high-efficiency particulate air (HEPA) filters and separate PPE donning and doffing areas outside. The operatory was fumigated every day after clinical procedures.

The mandibular arch impression was taken using an alginate impression material, then immediately disinfected with alcohol-based (71% to 80%) instant surface disinfectant (Bacillol 25, Raman & Weil, Mumbai, India) and sent to the laboratory in a sealed plastic bag to pour. The stone cast of the mandibular arch was then scanned using a desktop scanner (Maestro 3D Desktop Scanner, AGE Solutions, Pisa, Italy). The scanning time was approximately 3 minutes and 30 seconds, and the scanned cast was saved as a digital model in STL file format. The STL file was then cleaned and repaired using orthodontic CAD software (Maestro 3D Ortho Studio Software, AGE Solutions).

Digital setup began with tooth segmentation and the mesiodistal dimensions of the teeth were measured. After marking the mesiodistal dimensions, the software auto-





Figs 2a-b Software showing (a) three aligners (set of three models) to achieve the desired result based on automatic planning and (b) manual planning to limit the majority of tooth movement in the mandibular incisors to ≈0.59 mm to align the teeth using one aligner.

matically computed a trim line along the tooth margins. The next step involved completion of tooth segmentation and definition of the local axis of the tooth, followed by the final step of tooth movement (translation and/or rotation) individually or in a group to obtain the expected final position. The final position of the mandibular teeth was planned digitally and saved in STL file format. Initially, the automatic plan in the CAD software showed that a total of three aligners were required to achieve the desired tooth positions with 0.197 mm movement with each aligner (Fig 2a). As irregularities were only present in the mandibular incisor region and the COVID-19 pandemic necessitated a reduction in the number of patient visits, a decision was made to limit tooth movements to the incisor region. Thus, a maximum of 0.590 mm tooth movement was planned in the mandibular anterior region using a single aligner (Fig 2b). Interproximal reduction of 0.2 mm was performed at each interproximal contact in the mandibular incisors, extending from the mesial aspect of the lateral incisor on one side to the mesial aspect of the lateral incisor on the other to create space for the correction of the misaligned incisors. The final digital model was generated using a 3D printer (Objet30 OrthoDesk, Stratasys, Minneapolis, MN, USA) and printed with commercially available 3D printable material (VeroWhitePlus for the dental model and SUP710 PolyJet as support material, both Stratasys) in 3 hours (Fig 3a). The aligner

Figs 3a-d **(a)** Final 3D printed model; **(b)** fabrication of aligner on the 3D printed model; **(c)** aligner fabricated for the patient; **(d)** FSW retainer adapted on the same 3D printed model that was bonded post–aligner treatment.

Figs 4a-c **(a)** Intraoral photograph of the patient wearing the aligner; **(b)** posttreatment intraoral photograph with rebonded mandibular FSW fixed retainer; **(c)** STL file of superimposition showing the initial situation and final position.

was fabricated using a thermoplastic sheet (0.75 × 125.00 mm; Duran, Scheu-Dental, Iserlohn, Germany) and a pressure moulding machine (Biostar, Scheu-Dental), then trimmed and finished before being delivered to the patient (Figs 3b and c). The product datasheet for Duran states that its chemical composition is polyethylene terephthalate glycol (PET-G). The aligner was trimmed in straight line margins at 2 mm beyond the gingival zenith[14]. The same 3D printed mandibular model was used to adapt the mandibular fixed retainer using flexible spiral wire (FSW) and bond this FSW retainer onto the lingual aspect of the mandibular incisors during the next visit after correction with aligner treatment (Fig 3d). FSW retainers are multistranded (0.0150- to 0.0215-inch) bonded lingual retainers used as a means of permanent retention to maintain the alignment of the correctly positioned anterior teeth[15]. As per the recommendations, a five-stranded coaxial wire was used; this is considered the gold standard[16]. The flexibility of the wire helps to maintain periodontal health. The present authors used 0.0160-inch coaxial stainless steel wire (Ortho Organizers, Carlsbad, CA, USA).

Day 2

After the intraoral fit of the in-house aligner was verified, the aligner was delivered to the patient and she was instructed to wear it for 24 hours a day, except during meals and oral hygiene care. A follow-up appointment was scheduled for 2 weeks later.

Day 15

At the 2-week follow-up, the misalignment of the mandibular anterior teeth was found to have been corrected and the

teeth had been aligned to their normal position. The mandibular fixed retainer was bonded from canine to canine as per standard protocol during the same appointment. The standard bonding procedure was performed for the FSW retainer. The patient was advised to continue wearing the same aligner for 4 weeks as a retainer (Fig 4). The fit of the aligner was checked intraorally via visual and manual inspection and the position of the aligner was also verified to ensure it was completely flush against the teeth without any gaps, fitting snugly over the distal surfaces of the most posterior teeth.

Outcomes and follow-up

The present case report described a safe and successful approach to using CAD software, 3D printing and thermoforming to manage an orthodontic problem without the need for outsourced laboratory support. This may be a feasible option to treat mild orthodontic problems and prove useful during the COVID-19 pandemic.

Discussion

The COVID-19 pandemic, which originated in Wuhan, China in 2019, has now spread to over 200 nations throughout the world[17]. Dental practitioners and orthodontists were initially advised to treat only non-deferrable emergencies during the pandemic, such as pain or discomfort due to the sharp wire on a fixed appliance or bonded retainer, a broken bracket or tube, irreversible pulpitis pain and abscesses[11]. Patients requiring emergency orthodontic treatment and with no COVID-19 related history or symptoms should be treated with the appropriate PPE and in accordance with the guidelines set by their national/local authority[17-19]. Treatment may result in higher costs due to the requirement for PPE.

The duration of fixed orthodontic treatment ranges from 18 to 24 months and requires multiple visits at a 3- to 4-week interval over the course of treatment[20]. At the Division of Orthodontics and Dentofacial Deformities, the scheduled care of patients undergoing orthodontic treatment was abruptly suspended due to the national lockdown, and consequently many patients experienced complications due to this disruption of routine follow-up visits. In the absence of regular visits, Dental Monitoring (Paris, France) would be advantageous to track the patient wearing aligners. A recent study found that Dental Monitoring with Invisalign treatment reduced the number of appointments by 33.1%[21]. Dental Monitoring services are not currently available in New Delhi, India; however, in the present case, the patient visited on days 1, 2 and 15 of treatment, so there was no major requirement to monitor her.

Recent studies suggest that aligners are a suitable option to treat mild orthodontic problems during the COVID-19 pandemic as they reduce the number of follow-up visits and the spread of the virus[11,19]. Although clear aligners are useful for correcting mild to moderate orthodontic problems, treatment is dependent upon outsourcing laboratory services for clear aligner fabrication[8-10], a process that has become more complicated during the pandemic. As such, the present authors used a completely in-house facility for aligner treatment planning and manufacture. Aligner treatment comprises several steps, and the present report outlines the details of the clinical and laboratory procedures involved in in-house clear aligner fabrication and treatment. A recent systematic review found that aligners produced a result comparable to that obtained with fixed appliance therapy for correction of buccolingual inclination in the maxillary and mandibular anterior teeth[11].

Bushang et al[22] found that aligner therapy reduced treatment time by 67% as compared to conventional edgewise bracket treatment, and that doctor time varied depending on the experience of the treating orthodontist[22]. The clinical outcomes of aligner treatment can be comparable to those achieved with fixed appliance therapy for mild to moderate malocclusion[11] and also reduce the number of follow-up visits required; thus, in the current situation, orthodontists could consider using aligners to treat mild to moderate malocclusion. The pandemic is compelling and inspiring the orthodontic community to conduct further research with a view to making aligner therapy not only cost-effective, but also a clinically effective orthodontic treatment modality for complex cases[11,12].

In the present case, aligner treatment facilitated tooth movement in the anterior region to correct orthodontic relapse and reduced the total treatment time. The ability to manufacture aligners in-house facilitated rapid orthodontic care in this patient without needing to wait for laboratory

support from aligner manufacturers during the COVID-19 crisis.

Conclusion

The present case report discussed a completely in-house method of aligner manufacture and treatment planning. The desired tooth movements for the correction of orthodontic relapse were planned on the digital models, and specifically designed CAD software was used to generate models for the different treatment stages in STL file format. The STL file was used for 3D printing to create the dental model on which the thermoforming was done to fabricate the clear aligner.

Declaration

The authors declare there are no conflicts of interest relating to this study.

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