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Seamless Workflows for In-House Aligner Fabrication

Digant Thakkar[a], Akim Benattia[b], Yashodhan M. Bichu[c], Bingshuang Zou[d,*], Juan Fernando Aristizabal[e], Dhaval Fadia[a], Nikhilesh R. Vaid[f]

[a] Manav Rachna International Institute of Research and Studies, Haryana, India
[b] Private Practice, Tunisia
[c] Private Practice, U.A.E.
[d] Department of Oral Health Science, Faculty of Dentistry, University of British Columbia
[e] Department of Orthodontics, Valle University Cali, Colombia
[f] Department of Orthodontics, Saveetha Dental College & Hospital, Saveetha Institute of Medical and Technical Sciences, Chennai, India

A R T I C L E I N F O

A B S T R A C T

In-house aligner systems (IHAs), alternatively known as in-office aligners (IOA), in the strictest sense, refer to clear aligner systems wherein every aspect of the aligner fabrication from digital treatment planning (DTP) to the delivery of the orthodontic care is managed in the orthodontic office itself. Although still in its nascent stages, increased accessibility to chairside intra-oral scanners and office-based 3D printers, rapid advances in DTP software and aligner fabrication materials, have all helped the cost-effective concept of fabricating aligners in orthodontic offices, take a definite shape. The aim of this paper is to elaborate on the essential components of an IHA system and elucidate a systematic workflow for seamless in-house clear aligner fabrication with an emphasis on clinical reproducibility, along with a clinical illustration of a patient treated with IHAs. The authors believe that the development of a standard operating protocol for in-house clear aligner systems may help reduce the heterogeneity associated with IHA fabrication and subsequently allow meaningful comparisons with established commercial clear aligner systems of the day.

In-house aligners: Introduction and scope

The rapid evolution of digital technologies and advances in dental materials have helped clear aligner therapy (CAT) emerge as a promising alternative to traditional fixed orthodontic appliances (FAs). The meteoric rise of clear aligners has been driven not only by the patient's demand for esthetic, comfortable, and oral-hygiene-friendly treatment alternatives but also by various stakeholders' aggressive marketing campaigns and promotion policies.[1,2] Exponential development of Artificial Intelligence (AI) and communication technologies, has permitted increased viability and potential for the remote monitoring of orthodontic treatment, especially with CAT, and this has the potential to yield tremendous benefits to both clinicians and patients.[3]

A survey of Australian orthodontists in 2013 indicated that 73% of responders had used aligners to treat at least one case in 2012, with a median of eight aligner cases.[4] Ten years later, a recent survey of clear aligner practices among Australian orthodontists revealed that more than 93% of the responders now provide CAT and almost half of them reported treating between 21 to 100 patients annually.[5] This unprecedented increase in clear aligner usage echoes the increasing popularity of clear aligners as a treatment modality among orthodontists as well as patients. Although there are multiple advantages of large-scale commercially fabricated clear aligner systems, such as a well-developed workflow from an in-office intra-oral scan to digital treatment planning (DTP), to the mailing-in of the final clear aligners; continuously increasing laboratory costs, finalizing the DTP by technicians or manufacturers, time-consuming processes involved in commercial aligner fabrication and significant turnover time, all constitute potential disadvantages of commercially fabricated clear aligner systems,[6-8] which in turn have rekindled the interest of orthodontists in in-house fabricated aligner systems.

In-house aligner systems (IHAs), alternatively known as in-office aligners (IOA), in the strictest sense, refer to clear aligner systems wherein every aspect of aligner fabrication from digital treatment planning to the delivery of orthodontic care is managed in the orthodontic office itself.[9] IHAs technically do not represent a new concept for an orthodontist. Kesling, as early as 1945, followed by

* Corresponding author at: Department of Oral Health Science, Faculty of Dentistry, University of British Columbia, Vancouver, British Columbia, Canada 2199 Wesbrook Mall.

E-mail address: drzou@dentistry.ubc.ca (B. Zou).

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Table 1
Advantages and drawbacks of in-house aligners.

Advantages	Drawbacks
Possible to truly customize aligners for patients and coordinate the use of these aligners.	Initial investment in laboratory and allied equipment, thorough knowledge of their operation.
Possibility to minimize cost, making clear aligners more accessible for a larger number of patients.	Need for dedicated and trained support personnel for efficient aligner fabrication and delivery.
Convenience of laboratory support for appliance adjustments, saving time for both patient and orthodontist.	Absence of uniform protocol for any single proven IHA system
Opportunity of personal branding in a saturated clear aligner market	Paucity of evidence regarding the predictability and effectiveness of IHAs

Nahoum (1964), Ponitz (1971), McNamara (1985), and Sheridan (1993), all utilized aligner-type tooth movement appliances, much before the emergence of Invisalign. Throughout these advances, the basic principle of producing minor tooth movements with individual clear appliances did not change. Fabricating appliances by making physical impressions, pouring casts, sectioning individual teeth, rearranging them into proper alignment to obtain a final cast and repeating this process at every clinical appointment was an extremely laborious and time-consuming process.[10] With the rapid development and accessibility to chairside intra-oral scanners, 3D printers, DTP software, and aligner fabrication materials, the cost-effective concept of fabricating aligners in orthodontic offices has now taken a definite shape.[6,9,11]

IHA design and fabrication allow orthodontists to truly customize CAT systems for their patients, coordinate the use of these aligners, and minimize cost; making these aligners more accessible for a larger number of patients.[12] IHAs as compared to company aligners, also offer the convenience of laboratory support for appliance adjustments, saving time for patients and orthodontists.[6-8] Conversely, IHA fabrication requires dedicated and trained support personnel, an initial investment in the laboratory and allied equipment as well as a thorough knowledge of their operation. Table 1 highlights the advantages and drawbacks associated with IHAs.

Although IHAs are currently a small segment of the orthodontic aligner market, they are here to stay and grow as the number of orthodontists who manufacture their own aligners continues to increase daily. Meade et al.'s pilot survey of CAT showed that in-house systems were used by 21.63% of Australian orthodontists.[5] A survey evaluating the current state of education in post-graduate orthodontic residency programs regarding CAT and the digital workflow for in-house fabrication of clear aligners, found that thorough training and education of the technology used in CAT during residency improved residents' confidence and competence in utilizing IHAs in their future practice.[13] Sachdev et al.[14] evaluated the accuracy of tooth movements with in-house clear aligners in patients with anterior crowding not exceeding 4 mm and found that the overall accuracy of tooth movement with anterior clear aligners was 56.18%, while Kravitz et al. reported the overall accuracy of anterior Invisalign to be 41%.[15] A randomized controlled trial (RCT) carried out to compare the effectiveness and efficiency of the in-house clear aligners with the traditional fixed appliances in treating premolar extraction-based complex cases has indicated that in-house clear aligners can be effective as fixed appliances in achieving good occlusion when suitable teeth movement protocol is employed.[16]

The aim of this paper is to elaborate on the essential components of an IHA system and elucidate a systematic workflow for seamless in-house clear aligner fabrication with an emphasis on clinical reproducibility. The development of a standard operating protocol for in-house aligner systems may help reduce the heterogeneity associated with IHA fabrication and subsequentially allow meaningful comparisons with established commercial clear aligner systems of the day.

Workflow sequence for IHA fabrication

The complete workflow for the fabrication of IHAs essentially consists of the following steps: 1) Intraoral scan; 2) Digital treatment planning (DTP); 3) Exporting serial aligner models; 4) 3D printing; 5) Thermoforming of aligners; 6) Trimming of thermoformed aligners; 7) Packing and labeling. Fig. 1 illustrates a typical workflow for IHA fabrication with Orthodontist and Auxiliary roles and duration involved.

Work distribution is the key to success in any field and orthodontists personally cannot perform all the above steps by themselves, as it may affect the clinical workflow of the office. It is efficient to retain the diagnosis and DTP components with the orthodontist and delegate the remainder of the steps to a designated technician or office staff.

Description of individual workflow sequence components

Intraoral scanning

An orthodontic plaster model constituted one of the most important components of orthodontic diagnosis and treatment planning, that has nowadays, been largely replaced by intraoral scanners (IOS), especially as clinicians move towards the in-house fabrication of clear aligners or other orthodontic appliances. There are multiple IOSs available in the market, utilizing various advanced scanning technologies, such as the triangulation technique (used by Cerec, Dentsply Sirona), active wavefront sampling (used by True Definitions, 3M ESPE), and confocal scanning technique (used by iTero, Align Technology, and Trios, 3Shape). Confocal scanning technology is a faster scanning technology that captures images by focusing on an optical light beam with high-resolution visual images with improved accuracy and fewer distortions. Amornvit et al. compared the accuracy of ten different intraoral scanners and found that Trios series scanners showed the best scan results compared to other scanners.[17] This scanning step can be performed well by a qualified and trained assistant but the orthodontist can perform the final check for distortions. It is essential to dry the teeth before completing an intraoral scan, else voids and/or bubbles can be observed in the scan, which becomes more evident when switching off the color data of the intraoral scan (Fig. 2).

Digital treatment planning

After the IOS, the digital models will be exported or uploaded to the software in stereolithographic (STL) files. There are multiple CAD software packages available in today's market, from the simplest to the most complex, from the free to the onerously expensive ones. Most of them permit the designing of an aligner treatment, although with differences in the level of performance, based on the software selected. The software can be used separately or as a combination, such as OrthoAnalyzer (3Shape, Copenhagen, Denmark), SureSmile (Dentsply Sirona, Charlotte, NC, USA), OrthoInsight3D (MotionView software, Chattanooga, TN, USA), Formlabs PreForm (Somerville, Mass), SoftSmile (SoftSmile Inc., NY, USA), Orth'up (C4W, France), Archform (ArchForm Inc. CA,

Fig. 1. A typical workflow for IHA fabrication with Orthodontist and Auxiliary roles and duration involved. Icons in orange indicate orthodontist role and in blue, auxiliary role. Watch icons indicate actual time spent by orthodontist/auxiliary as opposed to total time mentioned individual boxes.

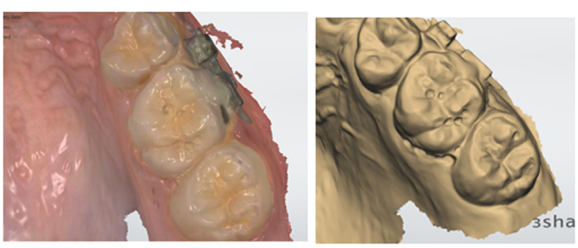

Fig. 2. Voids and bubbles present when teeth are not wiped to dry, especially when switching off the color feature.

USA), Bluskybio (BlueSkyPlan, IL, USA), and Ulab (uLab Systems, TN, USA).[18-21] Some offices also utilize off-the-shelf CAD/CAM to develop their own proprietary software.[8] Table 2 provides a comparison of the salient features of multiple commercial software in terms of the pre-processing, tooth movement planning and post-processing attributes.

From the authors' point of view, the principles and work sequence are quite similar for all these software packages and definitely, with the advancement of technology, user-friendly software with better aligner staging features will be developed. The basic steps of the software use can be described as follow: 1) Load or import scans: in this step a new case is created in the name of the patient and their intraoral scan is

Table 2
Comparison of multiple commercial software.[22]

	Archform	Blueskybio	Maestro	3Shape	Orth'up	SoftSmile	CsModel +	Deltaface	ULab
Pre-processing									
Base creation	√	√	√	√	√	√	√	√	√
Jaw orientation	√	√	√	√	√		√		√
Auto teeth segmentation	√	√	√	√	√	√	√	√	√
Creating arch forms	√	√	√	√	√	√			√
Overjet and overbite measurement			√	√	√	√			√
Tooth width analysis	√	√	√	√	√		√		
Virtual root		√	√		√	√			
Grid overlay reference	√	√	√	√	√	√		√	√
Planning (Tooth movement steps)									
Individual or group movement	√	√	√	√	√	√	√	√	√
Auto place attachment	√	√		√	√	√			
Customized attachment dimension/position		√	√	√	√	√	√	√	√
IPR adjustment	√	√	√		√	√	√	√	√
Staging IPR			√	√			√		√
Automated setup creation		√	√		√		√		√
Pontic for extraction cases	√				√				
Post-processing									
Printing horizontal	√	√	√	√	√	√	√	√	√
Printing vertical: add platform	√	√				√	√		√
Printing hollow	√	√				√	√		√
Label models	√	√	√	√	√	√	√	√	√
Automated Aligner trimming for milling machines		√		√	√				√
Subscription/License fee	√		√	√	√	√		√	√
Same day start	√	√		√	√	√	√		√

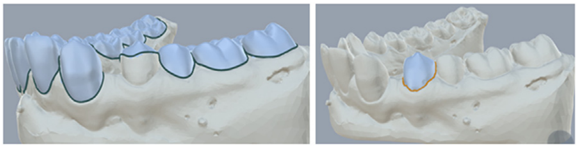

Fig. 3. A. Faulty lower first premolar margin defined, and B. First premolar margin corrected.

imported into the software, arranged, cleaned and a virtual base will be added. To enhance the efficiency of the 3D printing workflow and also reduce the amount of material and time required to print the model later, trimming the virtual base to a horseshoe shape matching the alveolar arch is recommended. 2) Segmentation: individual tooth margin is defined, and the tooth is separated in the upper and lower dentitions, which is very similar to a digital Kesling setup. 3) Visual treatment objective (VTO): teeth are moved according to the treatment plan. 4) Staging: segmental movements are planned to ensure there is space to move teeth toward their intended position. 5) Defining the number of aligners: some software complete this automatically while performing the VTO, whereas others require a special command to achieve the same. 6) Add attachments, some software possess an inbuilt feature for automatic attachment placement, while others need manual addition of the same.

This part of the workflow should essentially remain with the orthodontist, who should plan the intended tooth movements (steps 3 & 4), while an assistant or technician can take the lead for the other steps. However, the orthodontist still needs to supervise the following checklist: 1) compare loaded scans with the patient's name and intraoral photos; 2) check the individual tooth outline matches the cervical margin and interdental contacts (Fig. 3); 3) make sure all models are exported hollow and without any error from the software; 4) all models have proper labeling of patient's name and aligner step number. Although most of the software perform this automatically, some may require manual labeling, thus based on the choice of software, this constitutes a potential checkpoint.

A desirable feature of DTP while utilizing IHAs would be the power of control over biomechanical staging by the orthodontist, which more often than not, is the primary source of inefficiency of tooth movement noted with CAT. The majority of the commercial aligner systems have set protocols in place for this step and only allow the clinician to guide their lab technician on their choice of biomechanics. The ideal software for IHA fabrication would offer the orthodontist the flexibility of personalization to create biomechanically sound staging in appropriate periods of time for various types of malocclusions. Ideally, a single software solution should aim to provide as many automated features as possible to encompass all of the above-described steps.[9] In recent years, there has been a staggering surge of interest in intelligent systems as applied to everything from customer support to curing cancer; likewise, the applications of AI and machine learning (ML) in the field of orthodontics are also expanding.[23] DTP software systems can be expected to increasingly employ ML algorithms that help in accurate landmark identification and precise tooth segmentation within a minimal amount of time.[24]

Exporting 3D models

To reduce the material cost and the time required for model production, hollowing of the interior of models to possess 2 mm thick surfaces for sufficient strength when thermoforming aligners, needs to be achieved in the later stage. These parameters depend on the type of 3D printer and thermoforming machine of choice. One of the authors (DT) utilizes digital light processing (DLP) type of 3D printers and Ministar pressure forming machines with the above-mentioned values while exporting models. Once these models are exported, they are loaded in the 3D printing software.

3D printing

In-house 3D printing is regarded as a "disruptive technology" in orthodontics, which is cheaper, simpler, and more convenient and makes it possible to provide advanced services in affordable settings, empowering the specialists to take control of every aspect of aligner treatment and challenge both the dominance of sales-driven "big-brands" and the emerging "direct-to-consumer" challenge. It also makes "fusion" (hybrid) orthodontics both technically feasible and cost-effective on daily basis, whereby individual orthodontic treatments may be planned to seamlessly combine both fixed appliance and in-house thermoplastic phases. Hence, the orthodontist is able to undertake the most biomechanically challenging tooth movements and occlusal changes with fixed and/or TADs supported appliances, either before or after a pre-planned removable thermoplastic appliance phase.[12]

Clear aligners fabricated in-house employ 3D resin printing. Resin printing in orthodontics involves different types of Stereolithography (SLA) printing. There are three general types of SLA technologies commonly employed in orthodontic clinical care: laser SLA, DLP, and liquid-crystal display (LCD) masking. All these printing technologies have commonalities in that they all use 1) A photosensitive resin, 2) A light source, 3) A membrane, and 4) A build plate. The difference between laser SLA, DLP, and LCD technology is mainly the way in which the light is projected to cure the photosensitive resin. SLA printing uses a laser to cure photosensitive resin point by point. DLP uses a digital micro-mirror device (DMD) to produce a high-resolution projection to cure photosensitive resin a whole layer at a time, while LCD projection uses an LCD light source and a "masking" screen to cure a whole layer of photosensitive resin at a time. These differences affect the accuracy, speed, and cost associated with various printers. The accuracy requirements in orthodontic 3D printing are usually less than those in dentistry. Each of these printing technologies, when properly employed, can be used for the fabrication of in-house aligners.[12]

This is also the most important step in IHA manufacturing which many offices find extremely technique sensitive and difficult to follow, thereby giving up on IHAs altogether. One of the author's (DT) recommendations is the use of the DLP, since it possesses advantages such as speed, and constitutes a rapidly developing genre of printers with multiple options available in the market at differing prices.

Post-processing cannot be overlooked since this is a crucial step in the 3D printing of the models. 3D printed models should be washed in isopropyl alcohol (IPA) or tripropylene glycol monomethyl ether (TPM) by soaking and shaking in the solvent. In general, two washes will be needed to fully clean the 3D-printed models. A UV chamber is often required to achieve the post-curing by exposing the 3D-printed models to light and heat to help solidify the resin's material properties. Fig. 4 provides a stepwise illustration of a typical 3D printing workflow to obtain models for the in-house fabrication of thermoformed aligners.

One of the most critical requirements in the successful implementation of a seamless workflow for the fabrication of the IHAs is the understanding of the layout, setup, and functionality of a digital orthodontic lab. A detailed description of the considerations necessary for space planning and equipment needs for a digital orthodontic lab is beyond the scope of this paper and has been previously elaborated upon by Cope.[25] Fig. 5 provides a schematic illustration of the layout of an efficient lab setup for IHA fabrication.

Thermoforming of aligners

In-office aligners today, can be fabricated from both thermoformed materials and direct printing resins, however, this paper chiefly focuses on in-house aligner fabrication from thermoformed materials, as 3D direct printed in-house aligners are still in their nascent stages of development. The thermoplastic polymers most commonly used to manufacture commercial clear aligners include polyester, polyurethane or co-polyester, polypropylene, polycarbonate, ethylene vinyl acetate,

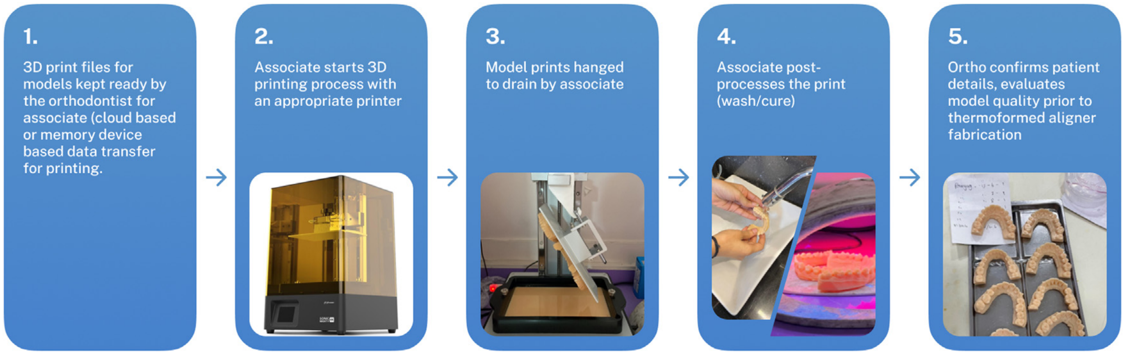

Fig. 4. A stepwise illustration of a typical 3D printing workflow to obtain models for the in-house fabrication of thermoformed aligners.

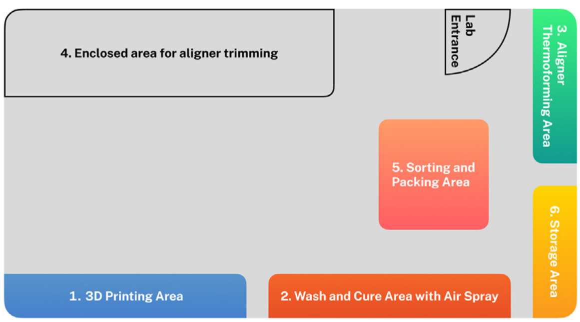

Fig. 5. A schematic illustration of the layout of an efficient lab setup for IHA fabrication.

polyvinyl chloride, and many other materials.[10] For IHAs there are different thermoformed sheets currently available commercially, such as Zendura (Bay materials), Essix (Dentsplay), Biolon (Dreve Dentamid GmbH), Clearaligner (Scheu Dental), Taglus stuff (Allure Ortho), Duran (Scheu Dental), Erkodur-al (Erkodent GmbH), among others.[21]

Thermoforming involves the shaping of the selected type of sheet or thermoplastic product with heat. Two types of thermoforming machines are commonly available: vacuum forming (Erkoform 3D motion) which operates on the principle of air depression and pressure forming (Biostar, Ministar, Erkopress) which generates pressurized air above the thermoplastic sheet to press it against the model, with pressure forming being more efficient and accurate. A compressor is required to warrant a tight fit between the aligner and the model.

Aligner trimming, labeling and packing

Once the aligners are thermoformed with the choice of thermoforming sheets they have to be trimmed out from the circular thermoformed mould. This trimming can be done using a bur set and micromotor or using specific aligner cutting scissors. The aligner margin can be kept straight and 2 mm above the cervical margin or can be trimmed along the gingival margin, with the straight-line cut known to have better retention and the gingival margin scalloping offering ease and comfort of aligner removal for the patient. Khosravi et al. have identified the aligner trimming protocol as a rate-limiting step in the process of IHA fabrication. The authors mention that the protocols in which aligners are trimmed with a disc or a hot knife, are time-consuming and limit the number of units produced per hour, whereas a smooth scissor cut helps minimize the polishing step, which can be subsequently achieved with an electric lab handpiece mounted medium coarse polishing bur with speed control options.[9] Automated aligner trimmers, such as Trimlign from Ortho-automation, provide an alternative to the above two methods for trimming aligners; along with automated handling of aligner pouches and kit labeling; however, a significant number of aligners may need to be fabricated per day to financially justify the additional expenditure of such units.[9] Fig. 6 depicts the conventional armamentarium employed for the trimming and polishing of IHAs.

Fig. 6. The conventional armamentarium employed for the trimming and polishing of IHAs.

Fig. 7. The use of customized zip lock bags for the packing of IHAs and branding of the orthodontic practice.

The packing of IHAs, provides the treating clinician with a unique opportunity of branding and standing out in the ever-burgeoning aligner market and can vary from a simple zip lock bag to a professionally designed and manufactured package. Zip lock pouches are available online or through local vendors, and one of the authors (DT) prefers these zip lock bags to be transparent on one side and opaque on another side. The opaque side is used to paste the label for the office branding, patient name, aligner number, and any instructions for the patient; whereas the transparent side is used to confirm whether the aligner was indeed packed and if it's the right number of the aligner matching its label. Furthermore, the orthodontist could develop a personalized aligner therapy starter kit that could include products such as aligner cases, aligner seaters or chewies, aligner cleaning tablets or foam among others. Fig. 7 depicts the use of customized zip lock bags for the packing of IHAs and branding of the orthodontic practice. Fig. 8 provides a clinical illustration of a patient treated with IHAs (Kind Courtesy: Dr. Akim Bennatia).

Development of a mechatronic digital workflow

IHAs can be used to treat all kinds of malocclusions which are suitable to be treated with commercial aligners, including a combination with the surgery-first approach. One of the authors (JFA) is in the process of development of a mechatronic digital workflow, which is part of what the author (JFA) defines as "Craniofacial mechatronics", that integrates clinical findings, digital modeling, and 3D printing, and includes three important stages of digitalization, conversion, and materialization. Digitalization is the first phase of this workflow, which includes collecting and organizing the diagnostic aids that will be necessary to provide a detailed diagnosis of the patient. This includes clinical photographs or facial scans, STL files from intraoral scans, and DICOM (digital imaging and communication in medicine) files from medical tomography (CT) or Cone Beam (CBCT) scans. In this stage, the treatment must be planned with the proper interpretation of the gathered information. The second step of this workflow is Conversion, the stage wherein manipulation of digital information is initiated, which corresponds to the CAD phase. In this phase, the STL and DICOM files gathered previously, are imported to the software (Orthosystem®, 3Shape, Copenhagen) to integrate the data in both files and obtain valuable information on the root and alveolar cortical status, which allow dental movements to be carried out directly on the longitudinal axis of the tooth and avoid periodontal disease. Materialization is the last stage of this digital flow process that consists of obtaining the printed models or the direct printing of aligners and corresponds to the CAM phase. The author (JFA) believes that "Craniofacial mechatronics" thus establishes in the contemporary world a new approach to our profession, where mechatronic engineering converges with its electronic, robotic and control components, associated with the MEDTECH industry, 4.0 industry and artificial intelligence.

Emerging trends and conclusion

Any aligner system chiefly comprises of two major components- digital planning and physical aligner fabrication and four possible combinations exist for the execution of these two steps, namely, large-scale commercially planned and commercially fabricated aligners, commercially planned and in-house fabricated aligners, in-house planned and commercially fabricated aligners and finally, in-house planned and in-house fabricated aligners. CAT is now an accepted mainstay of orthodontic treatment and the number of patients seeking this rapidly evolving treatment modality can only be speculated to increase in future with further advances in technology and biomaterials. Available data indicates that a series of plastic aligners alone cannot resolve all the variants of malocclusion routinely treated by our specialty. A practical panacea to improve the predictability of CAT is the addition of creative and customized adjuncts to CAT,[26] and IHAs offer orthodontists the flexibility of personalizing treatment mechanics, spurring a utopic thought that the pendulum of clear appliances fabrication may swing back to clinician control from existing large-scale commercial manufacturers.

The authors of this paper primarily focused on in-house planned and fabricated clear aligners with the intention of showcasing the scope, advantages and drawbacks, and sequential steps involved in achieving digital workflows for efficient aligner fabrication in the orthodontic office along with clinical illustrations of a patient treated with IHAs. Contemporary literature is unanimous that the predictability and/or accuracy of tooth movement and the clinical effectiveness of treatment outcomes obtained with CAT are associated with less accuracy or inferior occlusal outcomes than those achieved with FAs. Against this backdrop, the question of whether in-house fabricated aligners would be as efficient as those fabricated by established commercial companies, is bound to raise its head.

Khosravi et al.[9] have aptly mentioned that the heterogeneity associated with an in-office aligner system hinders the ability to determine the efficiency of this aligner system. Cope[25] has similarly outlined the lack of standard protocols as well as the nascent nature of IHAs as the primary reasons behind the inconsistencies noted in this particular aligner system and has also described how treating clinicians are currently establishing in-office aligner systems by combining their creativity with the suggested trial-and-error techniques from their peers, often broadcasted on social media platforms. The authors of this paper echo these sentiments and believe that the first step towards the determination of the efficiency of IHAs would be the development of standardized protocols for the fabrication of in-office aligners akin to those employed by large-scale commercial manufacturers.

Advancements in digital software, enhancements in desktop 3D printers and the introduction of 3D direct printing resins can be expected to further advance the scope and potential utility of in-house clear aligners. With the rapid emergence of new direct 3D printing aligner materials and the increasing cost of commercial clear aligners, clinicians have now become interested in 3D printed in-house (3DPIN) aligners. In September 2021, South Korean manufacturer Graphy showcased the world's first direct

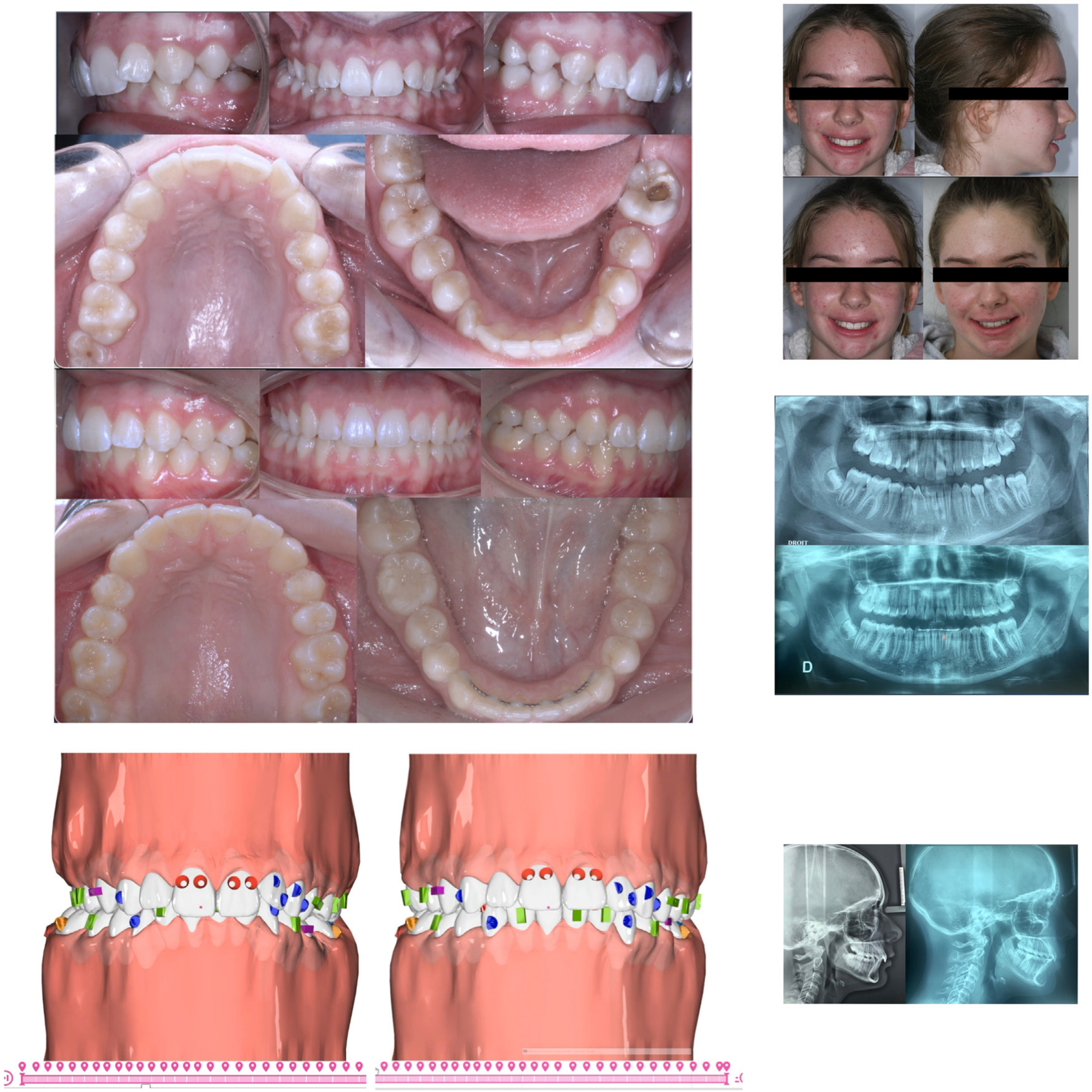

Fig. 8. A clinical illustration of a patient treated with IHAs (Kind Courtesy: Dr. Akim Bennatia).

3D-printed aligner, produced from the company's own 3D printing resin (Tera Harz TC-85), claimed to be equipped with a shape memory function, that the company mentioned, could be fabricated using any 3D printer. Owing to the direct production process, no printing models or vacuum forms are needed for 3DPIN, resulting in time and cost savings, apart from the environmental benefits of the reduction of plastic waste. 3DPIN aligners do have potential strengths, however, any commercially introduced resin must be tested extensively to demonstrate the practical effectiveness of its 3D printed aligner in a clinical environment.[10]

As has been succinctly summarized by Cope,[25] seamless digital orthodontic workflows mandate the integration of the linear flow of each individual procedure into a single effective and efficient process. An in-house aligner system, therefore, requires the coherent integration of digital tasks between the lab personnel, the clinical team, and the office scheduling coordinator, wherein each of the team members needs to accomplish specific sequential tasks matched with the overall office aligner delivery protocol. Furthermore, it is imperative for each of the team members to be familiar with the overall workflow associated with an IHA system yet continue to focus on the digital tasks that are specifically assigned to them.

Patient consent

Patient consent was obtained.

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Declaration of competing interest

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Author contributions

All authors attest that they meet the current ICMJE criteria for Authorship.

Editorial policy declaration

Given his/her/their role as Editorial Board Members, Bingshuang Zou and Nikhilesh R. Vaid had no involvement in the peer-review of this article and had no access to information regarding its peer review or final decision made.

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