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3-D PRINTED SPACE MAINTAINER

Paediatric Dentistry

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ABSTRACT

This review was carried out to highlight the drawbacks of widely used space maintainers and offer an understanding of the technological advancements made in the sector to address them. The rapid progress of digital technologies ensures a constant acquisition of fresh knowledge and fundamentally reshapes existing trends. While the concept of digital workflow is not novel, its implementation in pediatric dentistry is relatively recent. The creation of digital devices known as SMs is a result of exploration-driven curiosity. Their remarkable benefits of accuracy, comfort, and a time-saving method make them suitable for youngsters' use. By reducing chair side time and expediting procedures, this workflow helps youngsters become less fearful and improves their participation and enthusiasm for dental visits.

KEYWORDS

3d printing, digital, space maintainer, pediatric, workflow

INTRODUCTION

Space maintainers (SMs) are frequently used in pediatric dentistry when primary teeth have been lost prematurely(1). preserving the initial dental structure until the natural exfoliation process occurs is essential for speech, mastication, and aesthetics. However, it also helps with the proper eruption of their permanent successors and helps guide them (2). Unwanted effects of early primary tooth loss include opposing dentition supra-eruption, ectopic eruption, and shortened arch length (3). Space loss can be avoided by placing a space maintainer(SM)(4). Space maintainers (SMs) can be either unilateral or bilateral, fixed or removable. While removable space maintainers (RSMs) are more practical, fixed space maintainers (FSMs) can be more challenging to maintain clean (5). Traditionally, fixed appliances have been made from stainless steel (SS) and generally require impressions, fabrication of dental casts, and extensive hands-on time from a dentist and a laboratory technician(6). Although the digital workflow is not a novel idea in dentistry, pediatric dentistry has recently started to apply it. The creation of digital gadgets known as SMs results from exploration-driven curiosity. Their excellent features of comfort, precision, and a time-saving method make them seem potentially helpful for children. This process reduces chairside time and shortens procedures, which helps youngsters cooperate better and be less fearful of dental checkups. Digitainers or digital space maintainers are space maintainers who make use of this technology (5). The earliest known use of 3D printing in dentistry is from the early 2000s.

Its progress has accelerated in the last few years. The introduction of intraoral scanning and digital design process allows for the development of a band and loop SM, which can be customized for each patient and fabricated in a single appointment from an aesthetic material (6). This technique provides computer-aided design and fabrication in a digital process using intraoral scans, a milling machine, and CAD software (7). Digital technology has decreased the likelihood of human error by automating the production of dental models through three-dimensional printing (8). The materials fabricating a digital space maintainer are stiff, opaque, biocompatible, and composed of (PEEK) polyetheretherketone, bruxzir, and tailor. These materials combine a unique set of mechanical solid qualities. (9). Because of this material's natural tooth-colored appearance, patients who are allergic to metals or detest the taste or weight of metal can use it (10).

Space maintenance appliances are currently made using a digital workflow instead of the more traditional one because digital workflows have advantages over analog workflows (5).

Pediatric Dentistry's Digital Workflow

The digital workflow was first implemented in dentistry in the 1980s and has been used ever since. Lately, there has been great success in pediatric dentistry using CAD-CAM technology. The two primary benefits are increased patient acceptance of therapies and compliance. A small number of case studies that have been published show how successful digital restorations are for young patients both immediately and over time. The use of ceramic materials and CAD/CAM technologies in cosmetic dentistry is growing in adult and pediatric dentistry. According to several research, there are signs that CAD/CAM technology is being used in both permanent and primary tooth structures. (11)The advantages of resin nanoceramic CAD/CAM restoration for a patient lacking a permanent second premolar successor were investigated in a case study. A three-year follow-up on this restoration revealed that the resin nanoceramic CAD/CAM restoration was aesthetically pleasing and functional. (12) CAD/CAM A primary second molar with pulpotomy with PICN (polymer-infiltrated ceramic network) implanted showed good marginal fit, anatomical shape, and no discoloration. Nine months subsequently. (13). A 2-year follow-up research found that using in-office CAD/CAM technology on a young child with amelogenesis imperfecta improved quality of life and provided positive outcomes. This technique made restoring smiles, needing less clinical labor, and preserving tooth integrity possible. (14) Yilmazand Aydin claims that children find the digital impression approach more convenient than the traditional impression method(15).

This makes it possible to rebuild children's dentition with contemporary metal-free ceramic structures, producing restorations that are more robust, aesthetically pleasing, and functional(16). Pediatric patients may benefit most from rapid, accurate, and time-efficient CAD-CAM technologies(16).

Digital Space Maintainers

"Digital Space Maintainers" are space maintainers that use 3D printing or CAD-CAM technology and contemporary, biocompatible materials. Applying this technique could resolve the difficulties and disadvantages of conventional manufacturing.

1. Manufacturing Procedures Using Cad/cam Technology

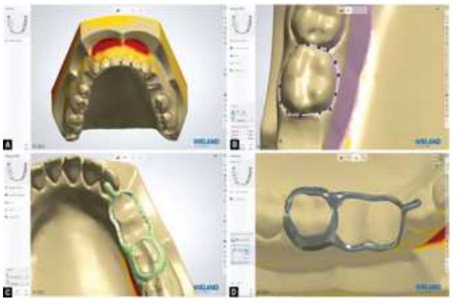
Using CAD-CAM technologies, restorations may be digitally designed and subsequently milled on an automated machine (17). Often, fabrication happens in a dental laboratory. A conventional imprint from the dentist is the first step in the CAD-CAM process, and it is then digitalized in the lab (18). The CEREC system, which Sirona invented, is the first chairside CAD-CAM technology that enables dentists to design and create restorations in the office (19).

Dental restorations can be completed more quickly when chairside and laboratory CAD-CAM manufacturing techniques are employed.

The workflow for digital restoration consists of three general steps: (1) Digital data collection via scanning the tooth, (2) software-assisted digital data manipulation to create the restoration's volume model, and

(3) methods for transforming the volume model into the restoration (20).

Below is a description of the process that Gerardo et al. (Fig. 4) used to construct a digital SM:



Figs 4 A to D "Digital pattern capture made possible using Gaetano Ierardo's device design and CAD software. This source is licensed under CC using NC-SA 4.0.

Step 1: After a dental impression is taken and the model is poured, an additional oral scanner is used to digitalize it.

Step 2: The scanned object is illuminated from all sides, and tiny cameras record it. The repeated scans produce a cloud of points that encompass the whole model. Connecting the dots and piecing together a pattern of little polygons results in the virtual model.

Step 3: The virtual model is immediately incorporated into the (CAD) software program after being obtained. The rotate, zoom, and panning tools allow the model to be viewed at different magnifications and from different viewpoints, which facilitates analysis and helps develop a customized gadget. With this technology, several parameters, including material t, retention, undercuts, thickness, and cementation space, can be determined, and devices can be built.

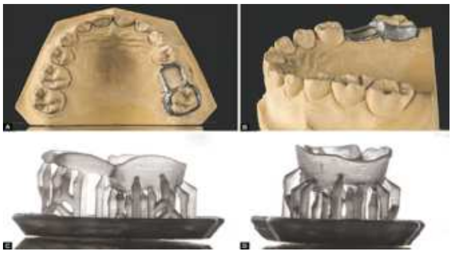
Step 4: At this stage, the file is moved to the CAM, where the manufacturing process starts with milling. In this manufacturing process, a block of selected material is subtracted using CAD software from a predetermined form (about one hour's work).

1. Three-dimensional (3D) Print Technology

Other names for 3D printing include solid freeform fabrication, layered manufacturing, and additive manufacturing. The fundamental idea behind this new technology is that a 3D object of any shape or geometry may be designed layer by layer using a digital file. Each of these layers represents a cross-section of the finished product. Pawar was the first to use digital three-dimensional printing to produce SMs (Fig. 5), one using powdered metal based on titanium and the other using clear photopolymer resin. As the author noted, there is much promise for 3D printing in pediatric dentistry(21).

Pawar et al. reported the first instance of band-loop space maintainers printed via 3D printing being manufactured. They used micro laser sintering technology in conjunction with powder metallurgy and digitally developed a space maintainer using a 3D model. The authors found that compared to traditional approaches, the design and production of space maintainers were more convenient and time-efficient when cutting-edge digital technology was incorporated. This demonstrates that 3D printing technology encourages potential in the field of pediatric dentistry (22). This result is consistent with another study that produced a 3D-printed space maintainer for a patient who was uncooperative by using titanium powder metallurgy and micro laser sintering technology. After the 3D-printed space maintainer was placed, they noticed a noticeable improvement in the child's cooperation.

Additionally, there were no indications of gingival irritation or plaque buildup on the 6-month follow-up appointment, and the 3D-printed space maintainer was still in place. The authors described the 3D-printed space maintainer's durability in its one-unit construction, which removed the necessity for welding and its exact modification that kept the occlusion intact. Additionally, they pointed out that the space maintainer that was 3D printed had a more intricate structure with more significant details. They came to the conclusion that, despite not being the most economical choice, the advantages of the 3D-printed SM exceeded the drawbacks (23). It is crucial to consider that the patient's oral hygiene habits may also impact decreased plaque buildup or gingival irritation.



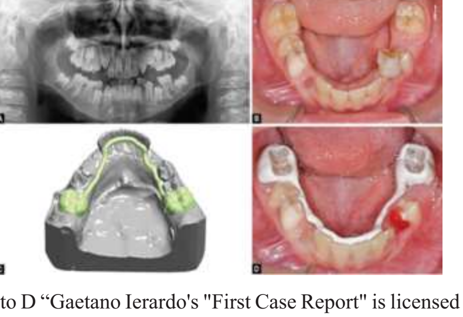
Figs 5 A to D

"Metallic three-dimensional printed space maintainers (A and B) made of powdered metal with a titanium base, and (C and D) made of transparent photopolymer resin via Bhaggyashri Pawar CC BY-NC-SA 4.0 governs the source license.

Materials Needed To Assemble A Digital Space Steward

Polymer Materials composed of polyetheretherketone. It is a thermoplastic, polyaromatic, semi-crystalline polymer that satisfies European and American (FDA) regulatory requirements and is certified from a nutritional standpoint [12, 29]. The biomedical, petroleum, chemical, and aerospace industries have used it [24]. It has been utilized as an implant material in dentistry and other medical specialties since 1998, replacing metal implants. This is because of its mechanical characteristics; like bone, it has an elastic modulus of 3.6 GPa. The semi-crystalline polymer PEEK has several advantageous properties, such as low affinity for plaque accumulation, mechanical strength, durability, biocompatibility, and lightweight. PEEK is a possible substitute material for producing space maintainers because of these qualities(24). Peek combines high mechanical qualities with rigidity, opaqueness, and biocompatibility in an unusual way. The material offers chemical resistance, dimensional stability, high-temperature stability, and various processing options(25). This material can be used by patients who are allergic to metals or do not like the taste or feel of metal because it looks and feels like natural tooth enamel. According to a 2015 study, PEEK has various advantages in orthodontics that make it a viable option for use as an aesthetically pleasing metal-free orthodontic wire (26). For functional, detachable forms of SMs, the framework and prosthetic teeth can be built in the same design module, resulting in a fully integrated design. This makes this method better than others that use artificial teeth and self-curing resin (26).

The creation of CAD-CAM using PEEK polymer was the focus of the study conducted by Ierardo et al. They produced a detachable plate (Fig. 3), a B&L (Fig. 2), and a lingual arch (Fig. 1). It was evident from after the nine-month mark that each of the three patients was happy with the gadgets. According to Kun et al. 41's evaluation, digital Band and Loop SMs composed of PEEK polymer were 75% lighter than conventional SMs in children with unilateral loss of either the first or second molar. In an experiment conducted in vitro, Guo et al.(27) compared conventional RSMs with digitally generated RSMs composed of PEEK polymer. According to the findings, digitally generated RSMs match the model well, suggesting that the method could be used in clinical settings(27). This is because digitally created RSMs would not need to be ground and polished, and the traditional production process involves too many steps that could cause errors during the polymerization shrinkage of self-curing resin.



Figs 1 A to D "Gaetano Ierardo's "First Case Report" is licensed under CC BY-NC-SA 4.0.

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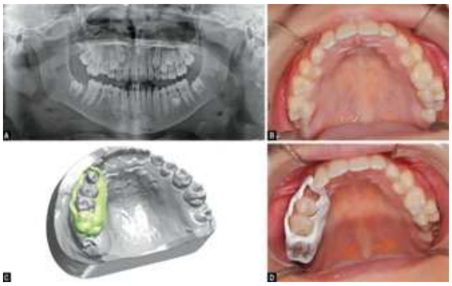
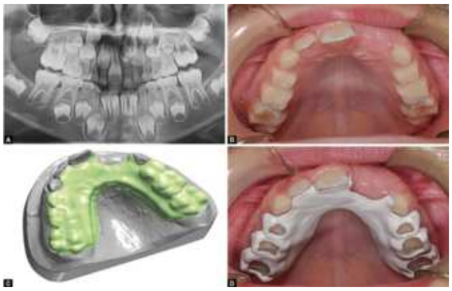


Figs 2 A to D “Gaetano Ierardo's "Second Case Report" is licensed under CC BY-NC-SA 4.0.



Figs 3A to D “Gaetano Ierardo's "Third Case Report," available at Source under CC BY-NC-SA 4.0

Bruxzir

Characterised with a maximum flexural strength of 1,465 MPa, BruxZir is 3 to 5 times more fracture-tough than regular zirconia(28). As a result, the material has outstanding impact resistance against the forces of mastication in the mouth. Because of its low thermal expansion, the substance will remain in your mouth without changing shape or becoming loose in your teeth. Soni's work was the first to be published on using digital technologies to create an SM(29).

The author used BruxZir as the material for the device while treating a six-year-old female patient (Fig. 4). The SM was made to be supported by the canine and the main second molar to hold the device in place. This made better appliance retention, a reduction in tooth tilting, and an even distribution of masticatory pressures throughout the extracted tooth's region possible. After six months of testing, the appliance worked flawlessly.

Trilor

Trilor is an FRC resin manufactured using CAD/CAM. This metal-free, biocompatible substitute weighs three to five times less than zirconia, a hefty substance. The advantages include biocompatibility, low weight, elasticity, repairability, and durability(30). Beretta and Cirulli created a metal-free CAD-CAM device to make safe gadgets for special needs patients who require routine magnetic resonance imaging (MRI) in the head area to check specific illnesses like epilepsy or vascular difficulties. They used Trilor to create a nance palatal arch, which they then directly bonded to the first primary molar's palatal surface(31).

CONCLUSION

Further investigation is required to explore the use of digital workflows in standard dentistry procedures. Assessing the impact of various materials, designs, and building techniques on clinical survival time is crucial, as is confirming the precision and dependability. Pediatric dentists now have access to less invasive, exact procedures that are more affordable for patients and professionals because of recent digitalization advancements. Additionally, these advancements may completely alter the current process for creating space maintainers, enhancing patient outcomes.

The research that is now available on the use of CAD/CAM technology to fabricate space maintainers in pediatric dentistry points to a bright future for getting past the constraints and challenges that come with using traditional production methods. The incorporation of digital processes into standard dentistry practice requires more investigation. Evaluating the effects of different building techniques, materials, and designs on clinical survival times is essential, as is confirming the precision and dependability. It is also critical to assess the machine costs and the training needs of those using this technology in clinical settings. Future research in these areas is crucial for enabling the practical application of CAD/CAM technology in pediatric dentistry.

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