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International Journal of Pedodontic Rehabilitation

Review Article

3-D Printed Space Maintainers - A Review

[1]Afritha Noureen Abbas, [2]Sharanya, [3]Joyson Moses

[1]Intern, [2]Professor, [3]Professor & Head of Department

Thai Moogambigai Dental College & Hospital,

Mogappair, Chennai – 600 107

How to cite: *Afritha et al, 3-D Printed Space Maintainers- A Review, Int J Pedo Rehab 2022; 7(2):19-24.*

https://doi.org/10.56501/intjpedorehab.v7i2.578

Received : 28.09.2022 *Accepted:20.11.2022* *Web Published: 21.11.2022*

ABSTRACT

Although the idea of a digital workflow is not new in dentistry, it has just recently started to be applied in pediatric dentistry. Fabrication of space maintainer is a time-consuming procedure that needs constant communication with the laboratory to be receive and provide patients the best outcomes. These devices maintain space created by premature tooth loss so that the erupting permanent teeth will not experience any kind of malocclusion. As a result of clinician's natural curiosity 3-D printed space maintainer have been developed. The advanced CAD/CAM technology used for fabricating digital space maintainers improves patient experience and compliance. The current paper provides an insight on available conventional space maintainers and various aspects of technologically advanced Digitainers.

Keywords: 3D printing, CAD/CAM, Pediatric dentistry, Space maintainers, Digitainers.

Address for Correspondence:
Afritha Noureen A, Intern
Thai Moogambigai Dental College & Hospital,
Mogappair, Chennai – 600 107
E-mail Id: afritha2000@gmail.com

INTRODUCTION

In primary dentition, exfoliation of deciduous teeth and eruption of permanent teeth is a physiological process. When a tooth is lost prematurely it disturbs this process leading to malocclusion. [1] One of the safest ways to prevent malocclusion from tooth loss is by using an effective space maintainer. [2] These devices maintain space created by premature tooth loss so that the erupting permanent teeth will not experience any kind of malocclusion. [3] There are various types of space maintainers according to their design, fixation, position, location which can be used specifically for a particular indication.[4] They broadly fall under the category of conventional space maintainers. With the advancement of digital technology, dentistry has shown tremendous growth in recent years. Space maintainers that use such technology are called as Digitainers/Digital space maintainers.[5] This article will review the various aspects of digital space maintainers and how it has overcome the drawbacks of conventional ones.

CONVENTIONAL SPACE MAINTAINERS:

Conventional space maintainers broadly include fixed and removable space types which has been widely used and recommended by pedodontists. Fixed space maintainers include the band and loop, crown and loop, distal shoe, glass fiber- reinforced composite resin, direct bonded which can be used for unilateral tooth loss. In case of bilateral tooth loss, lower lingual arch, trans palatal arch and Nance palatal arch space maintainers can be used.[6] Removable space maintainers can be functional and non-functional.

FIXED SPACE MAINTAINERS

Band and loop space maintainers - unilateral, passive, non-functional, fixed appliance indicated when a single posterior tooth is lost.[7] It has many variations based on the design.
Lingual arch space maintainer - bilateral, non-functional, mandibular fixed appliance used for minor tooth movement in lower arch.[8,9]
Trans palatal arch space maintainer - Unilateral, non-functional, passive, maxillary fixed appliance that has been recommended for stabilizing the maxillary first permanent molars when primary molars require extraction. [10]
Nance palatal arch space maintainer - Bilateral, nonfunctional, passive, maxillary fixed appliance approximating the anterior palate via an acrylic button without contacting the anterior teeth.[11] Used in case of bilateral premature loss of primary teeth with no loss of space in arch and a favorable mixed dentition analysis.[12]

REMOVABLE SPACE MAINTAINERS

They can be of two types, functional or non-functional and again may be unilateral and bilateral.[12] It has few advantages over fixed Space Maintainers such as being easy to clean & oral hygiene and can be used at the will of the patient.[13]
Application of removable or fixed type depends on factors such as the age, stage of development, occlusion, number of teeth lost, arch involved, and ability to cooperate.[14]

DRAWBACKS OF CONVENTIONAL SPACE MAINTAINERS:

Space maintenance plays a major role in pediatric dentistry and conventional space maintainers has been recommended and used by pediatric dentists for many years. But studies have found various drawbacks on using conventional space maintainers which are as follows.

- Nickel has been a potent allergen and studies have shown higher nickel sensitivity in children using intra oral devices containing nickel.[15]
- The widely used fixed space maintainers such as band and loop has higher chances of Decementation, breakage due to poor construction quality and causes ulceration.[16,17]
- The acrylic button in Nance palatal arch space maintainers causes tissue irritation, increases gagging.[18]
- Lingual arch space maintainers cause increase in occlusal load, interferes tongue movements.[19]
- The loop of the trans palatal arch space maintainer impinging the palatal tissue can cause trauma.[20] And also there is increased risk of root resorption as it positions the roots of the anchorage tooth against the cortical bone plate.[21]

DIGITAL SPACE MAINTAINERS – DIGITAINERS

Considering the disadvantages of conventional space maintainers, various studies explain the use of advanced technology and newer materials. Due to the benefits of a digital process over an analogue workflow, space maintainer appliances are now produced utilizing this method rather than the more conventional one.[5] By using three-dimensional printing to automate the creation of dental models, digital technology has reduced human mistake rates.[22] This method uses intraoral scans, CAD software, and a milling machine to provide computer-aided design and production in a fully digital process.

MATERIALS USED IN THE FABRICATION OF DIGITAINERS

Various materials such as polyetheretherketone (PEEK), bruxzir and trilor are utilized for fabrication of Digital space maintainers.

PEEK polymer, a linear semi-crystalline polycyclic aromatic polymer, was created by English researchers in 1978 for industrial purpose.[23] Belonging to the polyaryletherketone family, PEEK has an aromatic chemical structure with mixtures of ketone and ether functional groups between the aryl rings making it to exhibit stable physical and chemical properties.[24] It has great biocompatibility, strong mechanical properties, high temperature resistance, chemical stability, polishability, good wear resistance, low plaque affinity, and high bond strength with luting cements.[25] When compared to pure PEEK, PEEK modified with nanoscale zirconia exhibits the lowest wear properties and friction resistance, according to Wang et al[26] and Heimer S et al.[27]

Figure 1 shows the PEEK polymer used to maintain the space during the permanent incisor eruption.

Children with unilateral loss of either the first or second molars were studied by Kun et al.[28] who reported that digital B&L space maintainers manufactured of PEEK polymer were 75% lighter than traditional space maintainers. In vitro investigation, comparing the digitally produced removable space maintainers using PEEK polymer and conventional removable space maintainers, by Guo et al [29] revealed that removable space maintainers produced digitally matched the model well, proving the technique's suitability for clinical applications as it doesn't have multiple steps during fabrication that can lead to technical errors.

BruxZir is a solid monolithic zirconia material that uses CAD/CAM technology.[30] It has high flexural strength (up to 1,465 MPa) and exhibits three to five times the fracture toughness of typical zirconia [31] making it to offer greater resistance to masticatory forces in mouth.[5] Soni HK [31] suggested Bruxzir as the material of choice while treating a 6-year-old female patient with unilateral tooth loss, which was extracted due to chronic intra radicular abscess in 54.

Figure 2 shows the BruxZir used as space maintainer supported by canine and primary second molar.

Trilor is a techno-polymer that is made up of and reinforced by a multi-directional fiberglass matrix. It exhibits enormous strength while offering natural flex and natural load distribution.[32] It has been recommended for a wide range of aesthetic permanent metal-free dental prosthesis restorations on implants, including bridge frames, full-arch implant supra structures, and removable partial dentures.[33]

In order to provide safe appliances for patients with particular needs who need routine magnetic resonance imaging (MRI) in the head area to monitor certain conditions like epilepsy or vascular issues, Beretta and Cirulli [34] designed a metal-free CAD-CAM device. To immediately bond to the palatal surface of the first primary molar, they used Trilor to build a Nance palatal arch space maintainer.

TECHNOLOGY ENGINEERED IN FABRICATION OF DIGITAINERS:

CAD/CAM technology involves computer aided design and computer aided manufacturing making the patients to receive aesthetic, long lasting and well-fitting prosthesis.[35] The CEREC system from Sirona was the first chairside CAD-CAM technology, helping dentists to create and design restorations immediately in the dental office.[36] The CEREC system, created by Mormann and Brandestini, was the first CAD/CAM system to be made commercially accessible.[37] All CAD/CAM systems have three functional parts: data collection or scanning to gather and store information about the oral environment, CAD for data manipulation and designing and CAM for fabrication. Digital workflow involved in the fabrication process using CAD/CAM system is described below:[38]

Data capturing involves usage of intra oral digital 3-D scanning device. Data from models can also be gathered using mechanical or optical digitizers of various types. The CAD/CAM system's data-capture scanner is a key component and only works in conjunction with certain CAD software.

Commercially accessible CAD software tools are available for creating digital 3-D dental restorations on a computer screen. In most cases, the user can manipulate the automatically created design. The software applications are often exclusive to the CAD/CAM system and cannot be exchanged between systems, just as the data collecting systems.
The file designed using CAD software is moved to the CAM, where milling sets off the production of the device. Fabrication systems mostly rely on subtractive method in which to get the required shape out of a block, material is removed. Instead of cutting, there are certain technology that sinters material along the path, continuously adding material, until the intricate portion is finished (Additive method). Some CAD/CAM systems that are commercially available combine additive and subtractive CAM techniques.
Technologies for 3D printing can swiftly integrate CAD data. Additionally, it can quickly produce single and small-batch components, fresh samples, and products with complicated shapes, molds, and models. [39] Power bed fusion (PBF), light curing and fused deposition modeling (FDM) are the three main technologies of 3-D printing.[39] Pawar [22] was the first to use digital 3D printing to make space maintainers, making one out of transparent photopolymer resin and the other out of titanium based powdered metal.

ADVANTAGES AND DISADVANTAGES OF DIGITAINERS:

Advantages: [28-31, 40, 41]
3-D printed space maintainers are advantageous,

- In patients with metal allergy like nickel
- In patients that requires to undergo MRI of Head region
- By improving aesthetics
- By reducing processing errors
- By decreasing the number of appointments
-

Disadvantages: [30, 42]
The disadvantages of 3-D printed space maintainers are as follows,

- Expensive technology
- Try in appointment is missed
- Expertise skills required

FUTURE RESEARCH

The world is advancing technologically, and as we gain a greater grasp of its benefits and drawbacks, 3-D printing technology will continue to evolve and improve. Though CAD/CAM technology has deeply ingrained into dentistry, there aren't many investigations and clinical trials that have been conducted with 3-D printed space maintainers. Hence additional clinical research employing other low-cost materials is required.

CONCLUSION

Employment of 3-D printing technology in dentistry has benefited both clinicians and patients. The evidence of clinical practice reveals decreased the chair side time using this technology which has greater impact in pediatric dentistry. Despite so many advantages, the actual drawbacks must be addressed in order to advance materials and technology employed in fabricating digital space maintainers.

FINANCIAL SUPPORT AND SPONSORSHIP – Nil

CONFLICTS OF INTEREST - There are no conflicts of interest

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