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Space Maintainers in Paediatric Dentistry: Recent Insights

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1. INTRODUCTION

The oral health of a child is closely intertwined with their overall health. Primary dentition plays crucial roles in chewing, speech development, and stimulating the growth of the oral system. Additionally, primary teeth serve as guides for the eruption of permanent teeth.[1] Dental caries, a prevalent childhood disease, arises from a combination of biological and behavioural factors, disrupts these physiological processes.[2] In low- and middle-income countries, there is a notable increase in dental caries affecting primary teeth, particularly in regions experiencing severe early childhood caries (ECC). This trend is observed alongside shifts toward modern diets and lifestyle changes globally. Compounding the issue, untreated carious teeth frequently progress to cause pain, significantly impacting oral health and the well-being of children, their families, and communities.[3]

Due to child neglect if the dental caries is left unnoticed, they can cause irreversible damage to the structure of the tooth. Extensively damaged tooth if left untreated can ultimately lead to tooth extraction.[4] This premature loss of teeth is routine component in the field of paediatric dentistry. If left unaddressed, it may lead to orthodontic issues like reduced arch length, tooth shifting, crowding, and speech distortions, impacting the child's psychosocial well-being.[5] Space management aims to preserve or restore lost space to prevent malocclusions. Space maintainers are typically used to retain the space resulting from unilateral or bilateral premature loss of primary teeth in either dental arch.[6]

Conventional space maintainers have been effective in preserving dental arch space after premature tooth loss but it has its own disadvantages like patient compliance for impression-making and band adaptation, soldered loop fracture, which frequently results in repeated manufacture. To overcome these disadvantages, several new space maintainers have been introduced. Among which the most recent one is digital space maintainers made with 3D printing and CAD/CAM technologies, that offers enhanced efficiency and outcomes.[7]

This article has reviewed and summarized various aspects of recently developed space maintainers.

Conventional Space Maintainers and Its Challenges

Space maintainers (SMs) serve the critical function of preserving dental arch length when a primary tooth is lost prematurely, typically during the primary or mixed dentition phase. These orthodontic devices are designed with specific criteria in mind: they should not interfere with jaw and tooth development, remain stable and resistant, prevent the opposing tooth from extruding, avoid functional disruption, and ideally restore functions like chewing, swallowing, speech, and aesthetics.[8] However, SMs can also present disadvantages or complications such as soft tissue changes such as friction-induced hyperplasia, interlocking, tooth decay, gingival problems, and challenges with maintaining oral hygiene.[9]

The choice to utilize SMs is influenced by a variety of criteria, including as the child's dental age, the order and timing of tooth eruption, the time elapsed after tooth loss or extraction, the amount of bone surrounding the new tooth, and the particular arch type.[10] SMs are typically recommended when the successor tooth advances normally and the length of the dental arch has not been drastically shortened, and there is no disruption in the relationship between molars or canines.[11] They are also indicated to avoid the emergence of undesirable habits and deal with any concerns with self-esteem that may surface, especially after early tooth loss in the anterior region. [12]

SMs can be categorized as either fixed or removable, with the choice of appliance depending on the patient's specific treatment requirements. This categorization assures that the selected SM is in line with the actual objectives and specifications of the dental treatment plan.[13]

Traditional space maintainers (SMs) have been a staple in paediatric dentistry, but they come with notable challenges that warrant consideration. Studies have highlighted certain concerns associated with both removable (RSM) and fixed (FSMs) types of SMs. These include an observed increase in periodontal index scores and a heightened risk of bacterial growth within the oral cavity when these devices are in place.[14]
Nickel, a common component in some SMs, presents significant allergenic potential, particularly affecting children who may be sensitive to this metal. Research indicates that SMs generally exhibit higher nickel release rates compared to materials like stainless steel crowns.[15] For instance, in certain study it was found that B&L SMs released nickel and chromium in simulated saliva conditions.[16]
To address these potential health risks, it is recommended to explore alternative stainless-steel alloys that may release lower levels of nickel and chromium. Additionally, applying biocompatible coatings to SMs could help mitigate allergic reactions and reduce the risk of adverse oral tissue responses. These strategies aim to improve the safety profile of SMs, ensuring they meet both functional requirements and stringent health standards in paediatric dental care.[17]

Fibre Reinforced Composite Space Maintainers:
Recently, fibre reinforced composite has been employed as a space maintainer material with aesthetic appeal. There have been attempts to create space maintainers using newer materials as a result of technical breakthroughs. Glass fibre-reinforced composite resin is one such substance. Glass fibres consist of this transparent, semi-finished product. GFRCR has been used to make intracanal posts, permanent splinting, frames for bridges and crowns, resin-bonded bridges, and removable dentures.[18] As such, it seems that the GFRCR space maintainer is a good substitute for conventional fixed space maintainers. Employing these space maintainers requires no impressions or lengthy laboratory processes because they are easy to apply and just require a single visit. They are aesthetically pleasing, less heavy, take up less area in the mouth, and feel desirable.[19] It seems likely that the design of a band-and-loop space maintainer will promote better dental hygiene and reduce gingival tissue stress. But unlike traditional band and loop, the material is flexible, which enables massive movements for a given amount of force.[20]

Niti Bonded Space Maintainers:
One visit is all that is needed to apply the simple NiTi space maintainer chairside. The permanent first molar is attached to the buccal side of a composite dimple, which is then filled in with an explorer to form a composite tunnel that is only open on the mesial end. After that, a section of 0.016-inch NiTi wire is attached to the buccal side of the first premolar or primary molar and extends past the dimple. Using bird beak pliers, the free end of the wire is inserted into the tunnel made in the first molar's dimple once the composite has hardened on both teeth. This creates an active NiTi wire loop. The tunnel entrance is then coated with a tiny bit of bonding material to improve the attachment's durability. Due to the NiTi wire's special shape memory property, which distalizes and uprights the first molar, the loop gradually reverts to its original shape. The wire segment acts as a passive space maintainer until the second premolar erupts after the active correction is finished.[21]
The entire procedure can be completed in one visit, eliminating the need for steps like impression taking, band fitting, and soldering. The appliance allows for better oral hygiene maintenance due to its self-cleansing properties, which also leads to increased patient compliance.[22]

Preformed Space Maintainers:
Recently, prefabricated bands and loops have been introduced in dentistry. They can be placed in a single appointment, are quickly installed during the visit, take less time, don't require laboratory work, and are affordable. These appliances have an 84.4% success rate, according to certain research. The loops in prefabricated space maintainers are fastened to the middle third of the bands, which are selected based on the mesiodistal width of the abutment tooth.[23]
Preformed space maintainers were developed to reduce chairside time which is chair side-cementable, assemble able, and useable. The biggest drawback of this space maintainers is that it is easily fractured which may lead to repeated fabrication.[24]

Digitally Fabricated Space Maintainers:
Since the 1980s, the field of dentistry has progressively embraced digital workflows, utilizing tools like computer-aided design/computer-aided manufacturing, or CAD/CAM. The creation of space maintainers (SMs) in paediatric orthodontics has likewise adopted this digital approach, motivated by the shortcomings and restrictions of conventional fabrication techniques.[25] Three primary processes are usually included in the digital CAD/CAM workflow: intraoral scanning for data gathering, data processing with specialized applications, and SM manufacture.[26]
Because intraoral scanning is non-invasive, it replaced conventional impressions and been well-received by children. The idea not only makes taking impressions easier, but it also encourages improved patient participation by lowering anxiety and tension, making the dental experience a better one.[27]
The process for developing digital SMs, which begins with a precise traditional dental impression, which is then cast and digitalized utilizing an extraoral scanner. This scanning device captures multiple scans of the model using light beams and micro cameras, generating a detailed point cloud. The software then reconstructs a virtual model by connecting these points into polygons. Using CAD software, customized SM designs can be created with tools for zooming, rotating, and analysing the virtual model from various perspectives. Changes to the design that affect cementation space, undercuts, retention features, material thickness, and support points can be finely tuned using this software.
After the design is complete, the file is loaded into a computer-aided manufacturing (CAM) system so that it may be manufactured using a method called subtractive manufacturing—milling. According to the CAD design, the milling machine precisely carves the SM from a chosen material block; the procedure usually takes an hour or so to complete. As an alternative, digital files like the standard tessellation language/stereolithography (STL) format frequently used in dental applications are utilized to create 3D items layer by layer directly through 3D printing, also referred to as additive manufacturing. Accurate digital intraoral scanning images of the hard and soft tissue topography of the oral cavity are necessary for 3D printing and CAD/CAM technologies to be used in the construction of SMs. There is no separate wire component and band in these space maintainers. [28-30]

Materials Employed In The Production Of Digital Space Maintainers:
Various materials are utilized for the manufacture of digital space maintainers (SMs), each offering specific advantages and applications in paediatric dentistry. Materials suitable for SM fabrication include Zirconia (BruxZir), Trilor polymer, polyetheretherketone (PEEK) polymer, polymethylmethacrylate (PMMA), and titanium-based metals, offering diverse options based on specific clinical requirements and patient preferences. These advancements in digital dentistry not only enhance the precision and customization of SMs but also contribute to improved treatment outcomes and patient satisfaction in paediatric dental care.

Peek (Polyetheretherketone):
PEEK is a semi-crystalline, thermoplastic, polyaromatic polymer approved for use in medical and dental applications by Americans and Europeans (FDA) regulations. It has been widely used in chemical, aerospace, and medicinal industries since 1998. PEEK's mechanical properties, including an elastic modulus similar to bone (3.6 GPa), contribute to its suitability as an alternative to metals in dentistry.[31] Its extraordinary biocompatibility is defined by its non-toxic, non-immunogenic, non-mutagenic, and non-carcinogenic qualities.[32] Although PEEK is more aesthetically pleasing than metallic materials and is appropriate for individuals who are allergic to metal, its main drawbacks include high cost and limited colour matching in the anterior teeth area, which can be mitigated with the addition of colorants.[33]

PMMA (Polymethylmethacrylate):
PMMA is a thermoplastic polymer moulded under heat, derived from methyl methacrylate through radical polymerization. It has found widespread use in medical and dental fields, including as dental adhesives, implants, and prostheses.[34] PMMA exhibits aesthetic versatility due to the ability to incorporate fibres or pigments, along with being lightweight, resistant, and highly biocompatible.[35] However, microbial adhesion remains a concern, although this can be addressed by incorporating metal nanoparticles such as silver (Ag) and copper (Cu). PMMA's integration into CAD/CAM processes has enhanced its surface properties, mechanical performance, and biocompatibility, making it suitable for 3D-printed removable SMs.[36]

Zirconia (BruxZir):
BruxZir is a monolithic zirconia material known for its biocompatibility, high aesthetic potential, and excellent mechanical properties. It offers superior flexural strength (up to 1465 MPa) and minimal wear to opposing teeth, along with exceptional thermal shock resistance and dimensional stability. These characteristics make it appropriate for the fabrication of inlays, crowns, and bridges.[37] BruxZir can be customized to achieve desired shades, meeting aesthetic demands effectively. Its suitability for CAD/CAM fabrication ensures precise construction of SMs tailored to patient needs.[38]

Trilor Polymer:
Trilor is a thermosetting ethoxylene resin bonded with fiber-reinforced composite, glass fibres, offering good tensile strength, elasticity, and impact resistance. It is biocompatible, durable, lightweight, and repairable, making it suitable for various dental applications such as implant-supported prostheses, orthodontic retainers, and denture reinforcements. Trilor is particularly beneficial for patients allergic to metal or requiring periodic MRI scans due to its non-metallic composition.[39]

Titanium-based Metals (Ti):
Titanium alloys, such as Ti-6Al-4V and Ti-Al-Nb, are known for their lightweight, high strength, biocompatibility, and corrosion resistance. Widely used in orthodontics and dental implants, these alloys are suitable for 3D printing/additive manufacturing (3DP/AM) technologies, enhancing mechanical strength and fabrication efficiency.[40] Titanium-based metals are increasingly considered for SM production due to their practicality, efficiency, and suitability for patients with compliance challenges.[41]

These materials highlight the diverse options available in digital dentistry for fabricating SMs, each tailored to specific clinical needs and patient preferences.

2. CONCLUSION

Digital space maintainers (DSMs) made with CAD/CAM systems and 3-D printing have demonstrated encouraging results in paediatric dentistry. It offers advantages such as improved patient comfort, shorter production times, and significant aesthetic enhancements. One-piece fabrication has notably boosted device strength, biocompatibility, and stability.
Despite these benefits, challenges like cost implications and the requirement for specialized equipment and trained personnel hinder widespread adoption. Moreover, while initial results are positive, more extensive and long-term studies are necessary to fully assess the durability and effectiveness of CAD/CAM-produced DSMs.
Future research endeavours are expected to delve deeper into these technologies' potential, aiming to refine methods, enhance outcomes, and broaden access to advanced dental solutions for children.

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