CASE REPORT

Three-dimensional Printing Technology: Patient-friendly and Time-saving Approach for Space Management in an Autistic Child in COVID-19 Times

Padma Yangdol[1], Namita Kalra[2], Rishi Tyagi[3], Amit Khatri[4], Puja Sabherwal[5], Tavisha Goyal[6]

Abstract

Aim and objective: The present case report comprehensively illustrates the use of a novel digital three-dimensional (3D) printed band and loop space maintainer [computer-aided design and computer-aided manufacturing (CAD/CAM)] for the guidance of eruption with their distinctive attribute of reduced chairside time in a home-schooled autistic child.

Background: Three-dimensional (3D) printing is a promising and emerging technology in the arena of dentistry based on CAD/CAM. It has led to the production of customized 3D objects or patient-specific prostheses with accurate results achieved in a time-saving manner. 3D printing has been employed in several latitudes of dentistry; however, the applications are few in the field of pediatric dentistry.

Case description: The paper describes the space management of an autistic child for the missing mandibular left primary second molar through the novel technique of 3D printed band and loop space maintainer.

Clinical significance: The novel technique has definite advantages, including high precision, accuracy, fast production, and reduced patient exposure to dentists and vice versa, which has been the need of the hour since the advent of the coronavirus disease of 2019 (COVID-19) pandemic.

Conclusion: Three-dimensional (3D) printing minimizes dental aerosol-generated exposure by decreasing chairside procedural time and minimizing procedural sitting. The cost-benefit analysis, as applied to the Indian scenario, has also been computed, which makes it equally acceptable. Moreover, 3D printing reduces material waste production, offering a greener and environmentally friendly option in the coming years. The future of pediatric dentistry will evolve with signs of progress in the latest materials and technologies.

Keywords: Case report, Computer-aided design and computer-aided manufacturing, Digital dentistry, Three-dimensional printing, Space maintainer, Pediatric dentistry.

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Background

Three-dimensional (3D) printing, also called rapid prototyping, additive manufacturing, or desktop fabrication, is an advanced manufacturing technology based on computer-aided design and computer-aided manufacturing (CAD/CAM) technology using standardized materials to fabricate customized 3D objects through a layer-by-layer approach.[1,2] From a historical perspective, during the 1980s, the first 3D printing technology was developed by Charles W Hull, founder of the 3D system. He patented the first 3D printing machine called stereolithography in 1986. Subsequently, in 1989, Carl Deckard issued a patent for selective laser sintering. Scott Crump introduced the process of fused deposition modeling in 1990.[1,3] Over the years, the model has transformed into cross-sectional slicing and processing, which is sent to a 3D printer, causing layer-by-layer deposits of that particular material followed by postprocessing of the final object.[4–6] This advancement is proving to be a revolutionary technology for the development of customized products and devices across various fields, including medicine and dentistry.

With the advent of the coronavirus disease of 2019 (COVID-19) pandemic, dentists stand at the top of the chain of professionals predisposed to the infection. According to the Occupational Safety and Health Administration, dental healthcare personnel are placed in the "very high risk" category. Digital dentistry (CAD/CAM technology) may evolve as a boon and can reallocate its capabilities in the crucial COVID-19. In pediatric dentistry, the application of 3D printing is very promising, though unexplored. Therefore, in these unforeseen circumstances, there is a dire need to upgrade our pediatric practice with the utilization of this evolving technology to carry forward our "new normal." Moreover, decreased chairside time can be beneficial, especially for children with special healthcare needs. Thus, the present case report will elucidate the practical roles of pediatric dentistry with a 3D bioprinted space maintainer customized for an autistic child. We will also highlight its advantages

[1–6]Department of Dentistry, Pedodontics and Preventive Dentistry, University College of Medical Sciences (UCMS) and Guru Teg Bahadur Hospital, University of Delhi, Delhi, India

Corresponding Author: Namita Kalra, Department of Dentistry, Pedodontics and Preventive Dentistry, University College of Medical Sciences (UCMS) and Guru Teg Bahadur Hospital, University of Delhi, Delhi, India, Phone: +91 9958167711, e-mail: nkalraucms@yahoo.com

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and limitations as reviewed in the literature alongside our practical experience.

Case Description

A 7-year-old girl reported to the Department of Pedodontics and Preventive Dentistry with the chief complaint of a decayed tooth and difficulty chewing food in the lower back tooth region. The patient's medical history included a diagnosis of autism spectrum disorder. A previous dental history revealed extraction of a tooth done under local anesthesia using active restraints from a local dental clinic, as reported by the patient's mother. On clinical examination, it revealed multisurface caries with 85 and missing teeth with 75. A periapical intraoral radiograph depicted that the bone coverage over the tooth is >2 mm, and the space for the succedaneous tooth should be maintained for 2 years, which is suggestive of a fixed space maintainer. The management was done with diet counseling, education, and brushing demonstrations for the parents. To build rapport and gain the confidence of the child, the first visit included a tour of the clinic, modeling, and the tell-play-do technique was employed. On the second visit, a picture exchange communication system approach was applied. On the third visit, a single step lower alginate impression was taken and was poured to make a cast. Subsequently, on the following visit, a stainless-steel crown was delivered using the Hall technique with respect to 85.

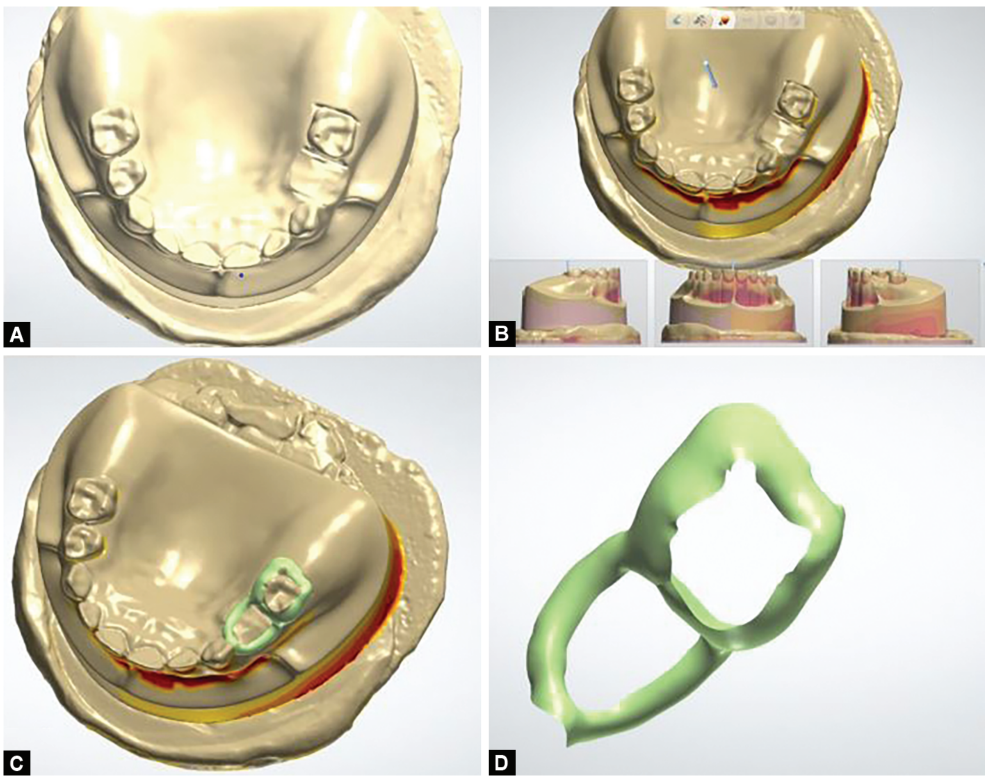
Designing, Fabrication, and Treatment Process

Initially, an ideal primary cast dentition was poured for a trial design of a 3D printed space maintainer by digital scanning and designing. The retrieved cast was sent to the 3D printing laboratory for scanning and printing for the 3D printed band and loop space maintainer. The cast was scanned using a 3D digital dental scanner (3D shape digital lab scanner), followed by the designing of the band and loop similar to the conventional space maintainer using the partial denture module of 3Shape dental system software as no specific software exists for designing such appliances (Figs 1 and 2). The fabrication took place by DMLS (direct metal laser sintering). The biomaterial used for the fabrication is cobalt-chromium (Co-Cr) base alloy as a metal-based band and loop space maintainer (Fig. 3). The 3D printer used for the processing was Shinning 3D DMLS printer. Final finishing and polishing are done (Fig.4).

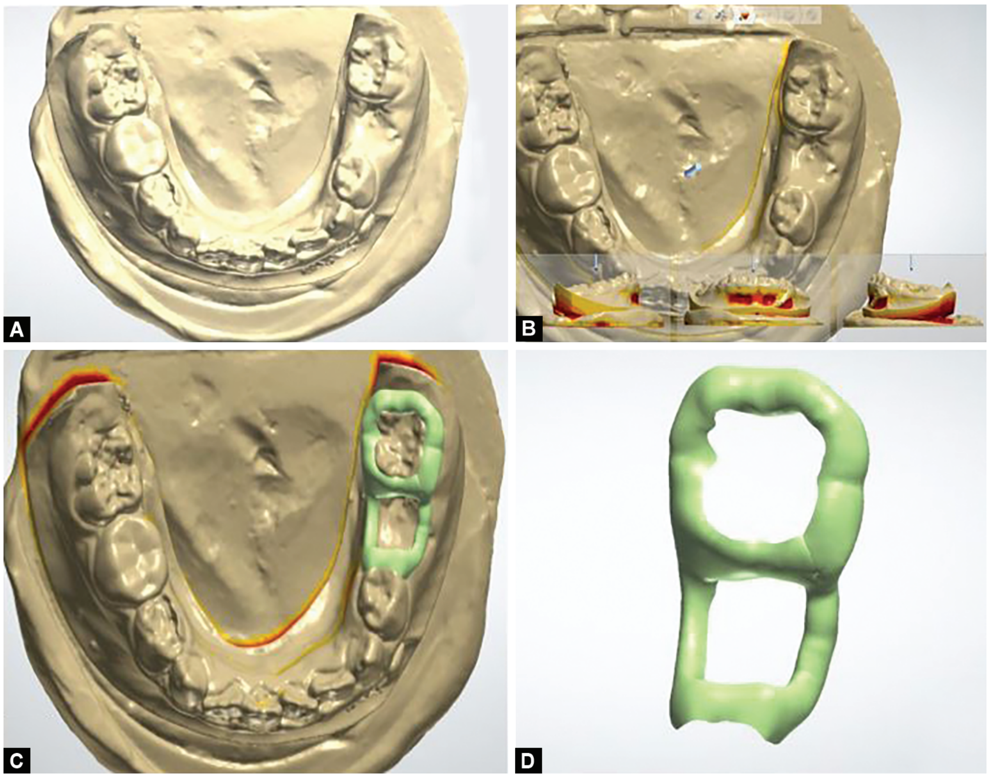
The printed 3D space maintainer was tested in the patient's mouth, and adaptation of the appliance was done and cemented with glass ionomer cement (FX ULTRA, SHOFU). The patient was instructed to avoid hard food and eat and drink for 30 minutes (Fig. 5).

Discussion

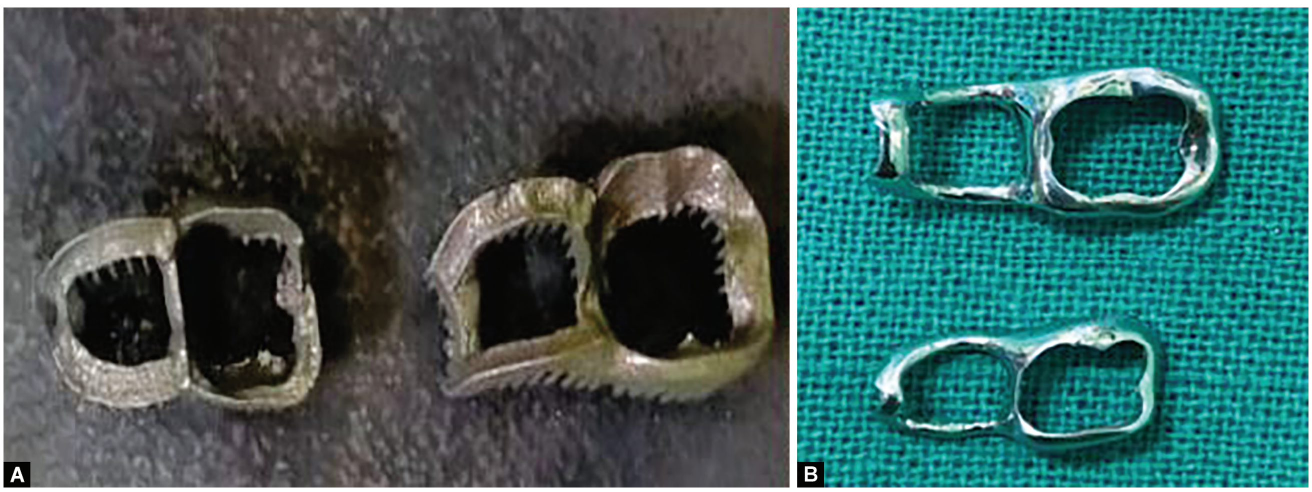
Premature loss of primary teeth frequently leads to unwanted tooth movement, resulting in loss of arch circumference, malpositioning, and even impaction of the permanent tooth in the primary and mixed dentition stages. Moreover, they have other detrimental effects, including drifting of the adjacent teeth, midline shift, and space closure, leading to crowding in the permanent dentition. Space maintenance in pediatric and preventive dentistry plays a crucial role in maintaining arch integrity.[7] Band and loop space maintainers are the most commonly used space maintainers for premature loss of primary molars and for guidance of eruption.[8] The conventional technique for the fabrication of band and loop space maintainer has certain challenges and shortcomings, such as patient compliance, long chair side time and construction time, caries formation along the margins of the band, solder failure, and inadequate band pinching.[8,9]



Figs 1A to D: (A and B) Showing the digital image of the maxillary ideal cast with wax block out of undercuts; (C and D) Depicting the digital design of the band and loop space maintainer on an ideal maxillary cast similar to conventional on the 3-shape dental system software



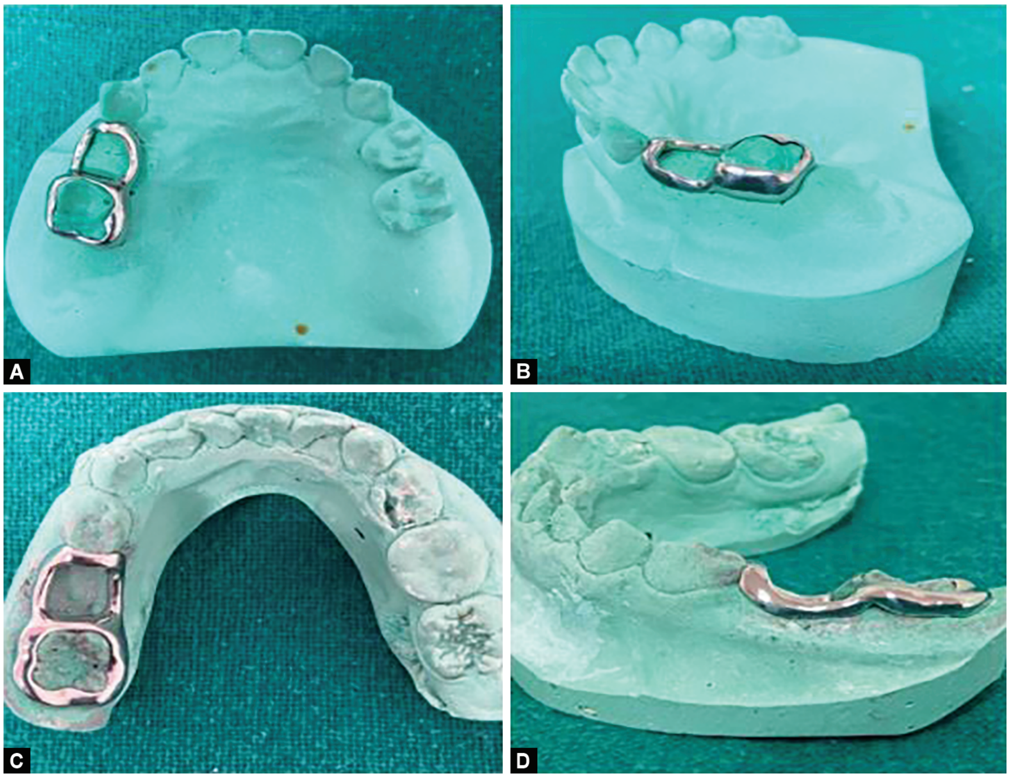
Figs 2A to D: (A and B) Showing the digital image of a mandibular 9-year-old autistic child cast with wax block out of undercuts; (C and D) Depicting digital design of the mandibular band and loop space maintainer similar to conventional on the 3Shape dental system software



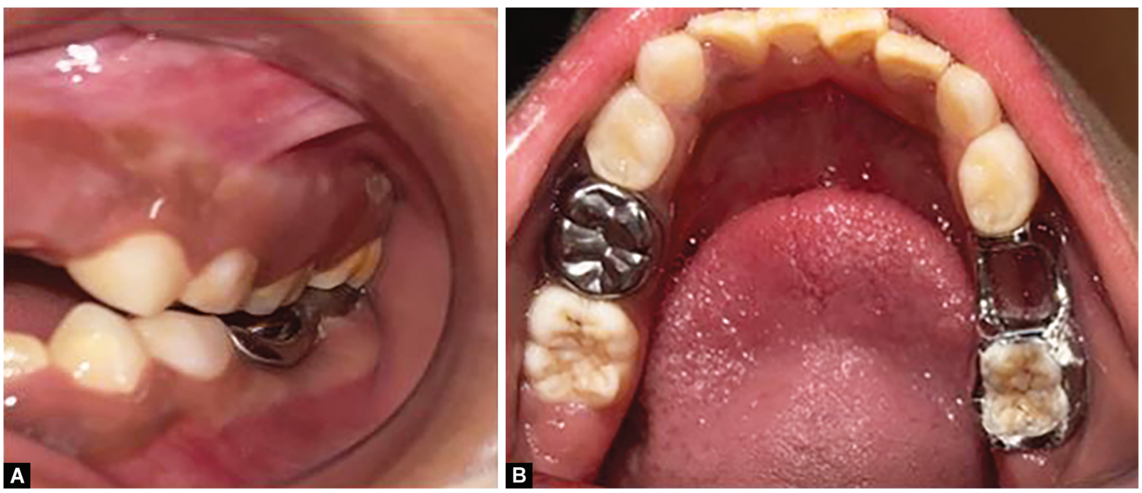
Figs 3A and B: (A) Prefinal outlook of 3D printed cobalt- chromium base alloy metal-based band and loop space maintainer; (B) Final outlook of 3D printed Co-Cr base alloy metal-based band and loop space maintainer

A novel digital rapid prototyping technology of 3D printing, a process of obtaining the 3D model and transferring it in STL format, preparing the print model by layering and slicing the data in the 3D printer and the final 3D products formed (Fig. 6).[10] Biomaterials used for the fabrication of 3D dental materials are ceramics, hydrogels, thermoplastic, and polymer-based materials and metals.[2] In the 3D printed dental prostheses, titanium and chromium-cobalt are the most favorable materials used. Several studies demonstrated that Ti6Al4V has a high capability for maxillofacial prosthesis, and Co-Cr alloys having a higher hardness, good corrosive resistance, and higher bonding capacity led to preferred 3D printed dental materials.[11,12] In our present case, we have used Co-Cr alloys for the fabrication of space maintainers as they are a more cost-effective biomaterial than titanium alloys. The strengths and weaknesses of 3D printing in the fabrication of band and loop space maintainers are listed in Table 1.

Three-dimensional (3D) printing has enabled as an evolving technology with applications in the various dental fields such as in endodontics (tooth models, guided endodontic access, endodontic surgery template, etc.), prosthodontics (3D printed crowns and bridges, 3D printed complete and removable dentures), dental implantology, oral and maxillofacial surgery(contour models, surgical guides with reconstruction



Figs 4A to D: Three-dimensional (3D) printed Co-Cr base alloy metal-based band and loop space maintainer on the cast



Figs 5A and B: Cemented 3D printed space maintainer appliance

plates, occlusal splints, surgical implants, osteotomy guides in distraction osteogenesis), orthodontics (dental models, surgical 3D template for orthognathic surgeries, 3D metal printed mini-implants and individualized appliances such as clear aligners, customized ceramic bracket and archwires).[1,2,13,14] Applications of 3D printing in pediatric dentistry are presurgical nasoalveolar molding, crossbite correction, myofunctional appliances, orthodontic bracket, regeneration of the tooth and supporting structures and zirconia crowns, etc.[2,15–17] Although, the use of 3D printing in pediatric dentistry is still yet to be explored. Digitization has allowed us to shorten treatment time and provided opportunities to customize various treatments by improving the diagnosis and treatment planning capabilities. Simultaneously, in the cases of children with special healthcare needs children, decreased chairside time, utilization of fewer instruments, and quick and easy procedure in the fabrication of space maintainer through 3D printing has been beneficial to their community.

Assessing the Cost–Benefit Ratio in the Indian Scenario

The huge economic crisis during the COVID-19 pandemic has led to an increase in the current consumer price index inflation rate, wherein the inflation rate of January 2021 was 4.06. "Lower" and "upper–lower" categories (Kuppuswamy scale) for socioeconomic status cannot afford the basic health benefits. In view of that,

Table 1: Strengths and inadequacies of 3D printing in the fabrication band and loop space maintainer[1,2,6,18]

Strength	*Weaknesses*
• Increased precision and accuracy. • Minimizing human error. • Extensive strength and durability. • Decreased chairside time by omitting the long construction time of banding directly on the teeth and stabilizing the loop during delivery, thereby highly favorable to special children and during the COVID-19 pandemic. • Reduction in extensive laboratory work such as fabrication of loop, soldering, and polishing. • Decreased the tendency of disintegration of cement, minimizing solder failure by enhancing treatment procedures. • Minimizing breakage (printed as one unit). • Easy storage of fabrication records and models digitally.	• Expensive 3D printing equipment. • Complicated designing and procedure fabrication with complex postprocessing. • Costly biomaterials. • To consult for professional help for designing and manufacturing.

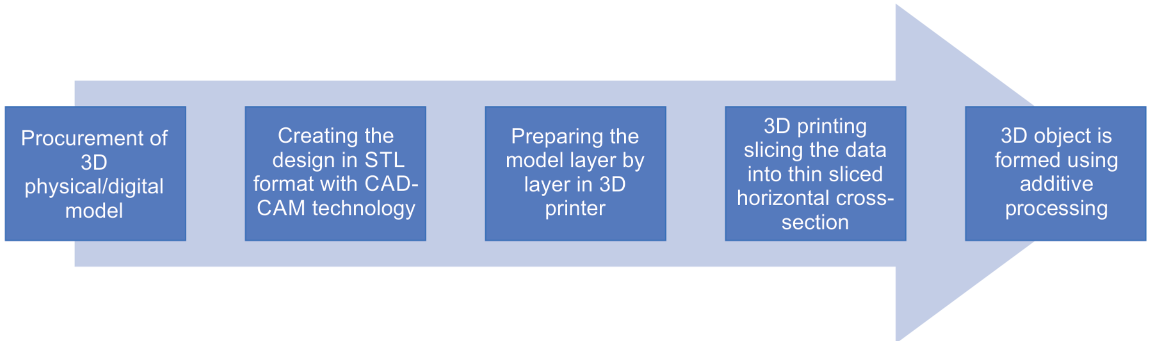


Fig. 6: Process of 3D printing

we resolved the financial aspect in the present cases by use of partial self-funding alongside the remaining subsidy provided by the collaborating dental labs' partners. This was done for optimal care and study purposes for the patients belonging to the low socioeconomic strata. Such laboratory-doctor-patient partnerships could be a possible alternate financial solution. Further, state and national dental organizations and governmental and nongovernmental organizations may advocate for, partially support, and fund the use of environmentally friendly and time-efficient technology like 3D printing in the COVID-19 scenario.

Conclusion

As budding clinicians in the field of pediatric dentistry, we adopted 3D printing to maximize the biological, functional, and esthetic needs of our patients. The present 3D bioprinted space maintainer technology demonstrates a high degree of accuracy and rapid results while minimizing chair side time and dentist–patient interaction. This may be the need of the hour in the COVID-19 pandemic era and a huge advantage for children with special care needs. The patients and parents showcased an excellent degree of satisfaction posttreatment. Many children with special health care needs may be supported by nongovernmental organization (NGOs) and other organizations, and NGOs may be tapped for the benefit of these patients. Thus, 3D printing may be a step toward the future of "smart," "green" pediatric dentistry.

Orcid

Padma Yangdol https://orcid.org/0000-0001-9477-1372
Puja Sabherwal https://orcid.org/0000-0002-2029-7951
Tavisha Goyal https://orcid.org/0000-0001-8674-4016

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