

Digitalization in Pediatric Dentistry

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Abstract

Digitalization has revolutionised all the branches of dentistry. Pediatric dentistry has also advanced leaps and bounds with the advent of new technologies. The use of digital tools such as CBCT, for diagnosis has greatly increased the probability of establishing the correct diagnosis even in complicated cases.

Digital technology provides for storage and sharing of patient records on cloud thus facilitating data sharing when an inter-disciplinary team approach is required for the benefit of patients. Simulations of final treatment outcome go a long way in establishing communication with parents and children thus building trust.

Digital impressions made through intra oral scanner, not only increase accuracy but also make the process of impression making easier for the child thereby increasing compliance. There has been a marked reduction in human errors by automating the process of fabrication of various dental appliances and dental prosthesis through 3D printing.

3D printing or additive manufacturing has various applications in pediatric dentistry, such as, manufacturing of Space Maintainers, Myofunctional Appliances, Paediatric Crowns, Naso Alveolar Moulding in Cleft lip and palate etc.

This article aims at providing an insight into the applications of digitalization in the field of pediatric dentistry. It attempts to familiarise pedodontists with the steps involved in establishing a complete digital workflow in their practices.

Keywords: Computer Aided Designing, Computer Aided Manufacturing, Intra Oral Scanner, 3D Printing, Additive Manufacturing, Naso Alveolar Moulding, Cleft Lip and Palate.

INTRODUCTION

Digitalization has taken dentistry by storm. Digital workflow has revolutionized the way dentistry is practiced the world over. The vast amount of data availability and the technical means to effectively leverage them has led to the paradigm shift toward digital dentistry. Nowadays digital dentistry is more than computer-aided design and manufacturing (CAD-CAM), it encompasses investigations, diagnostics, decision-making, treatment planning, and re-evaluation as well as long-term management of patients' oral health.^[1]

With the advent of digital planning, pre-visualization software, and the increased use of intraoral scanner systems in dental offices, communication with patients, in terms of explanation of treatment planning goals has significantly improved, leading to greater operative and psychological comfort of patients.^[2] In recent years, digital dental technologies have played a pivotal role in changing the way of approaching patients and designing innovative and more comprehensive treatments. Complete digital workflows are permeating every aspect of all specializations of dentistry.

Pediatric dentistry is no exception to this era's rule of digital dentistry. Pediatric dentistry has advanced leaps and bounds under the influence of this new technology. Improved patient compliance, increased pace, and improved accuracy of treatment, leading to acceptance of treatments by parents as well as the child patient.^[3]

USEFUL DIGITAL TOOLS IN PEDIATRIC DENTISTRY

Early drivers in digital imaging include both the evolutions in digital radiography and intraoral imaging systems.

With the evolution of digital technology has come an array of promising diagnostic aids; digital photographs, digital

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radiographs, and cone beam computed tomography (CBCT), to name a few. CBCT being the forerunner has found several applications in pediatric dentistry. All CBCTs provide additional information that assists in diagnosis, treatment planning, and management most significantly.^[4]

Real-time imaging, made possible through intraoral scanners, provides on-screen digital images of single or multiple teeth, whole arches, opposition arches, occlusion, and surrounding soft tissue.^[5] Digital impressions made through intraoral scanners not only increase accuracy but also make the process of impression-making easier for the child, thereby increasing compliance. Moreover, intraoral scanner systems featuring near-infrared transillumination have proved to be a potential diagnostic aid for the detection of proximal caries.^[6]

Various software has made digital dental model analysis and digital tracing of lateral cephalogram possible, thus greatly facilitating the clinician's decision-making while planning the treatment for a given case. In addition, such virtual planning may provide many advantages over the traditional approaches, for efficient storage, digital manipulation with reduced manipulation errors, and the ability to superimpose the stages of treatments at different time intervals.^[7]

These optical scans obtained through intraoral scanners are used to create digital models on which appliances and prosthesis for pediatric dental patients are designed through CAD software and manufactured through CAM.

3D printing or additive manufacturing has various applications in pediatric dentistry, such as the manufacturing of space maintainers, myofunctional appliances, pediatric crowns, appliances for Naso

Alveolar Molding (NAM) therapy in cleft lip and palate patients, night guards, and appliances for sports dentistry.

This article aims to highlight the clinical applications of 3D printing in a modern-day pediatric dental practice.

APPLICATIONS OF CAD/CAM IN PEDIATRIC DENTISTRY

Absence of permanent successor

Retention of primary teeth beyond their expected time of exfoliation is encountered relatively frequently. Most commonly, this is due to the absence of a permanent successor. Careful assessment is critical for all patients with retained primary teeth. Clinically, this should focus on the coronal shape, color, and structural integrity of the primary teeth.^[8] Where the crown and root structure of the tooth is good but infra-occlusion has occurred or esthetic improvement is required, the primary tooth may be retained and reshaped. A case report (Figure 1) presents the clinical use of a resin nanoceramic CAD/CAM restoration of a primary second molar without a successor in the form of a permanent second premolar tooth in a patient. Three-year follow-up of the case revealed that resin nanoceramic CAD/CAM restoration of the primary molar without successor achieved both esthetics and function. Despite the high cost of treatment, this type of restoration should be considered if the retained tooth is expected to maintain functionality over the long term.^[9]

Amelogenesis imperfecta

Amelogenesis imperfecta is a genetically transmitted disease consisting of a structural defect of the enamel that changes both

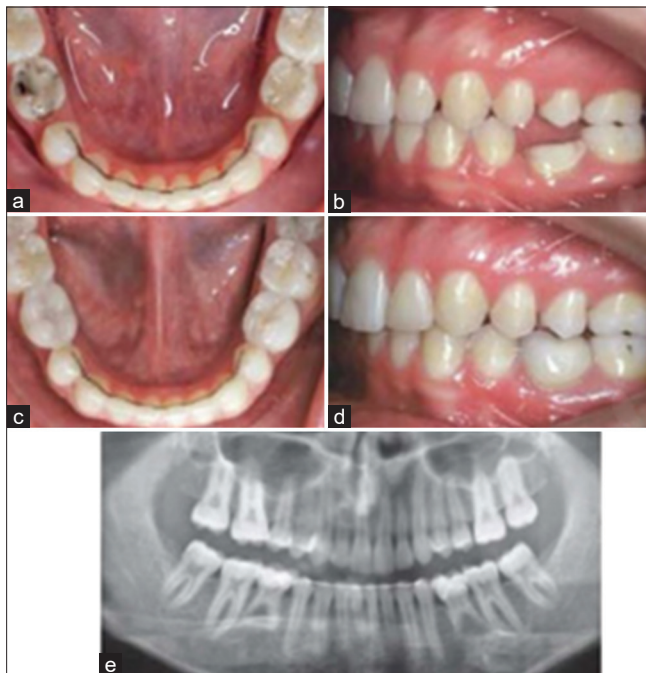


Figure 1: (a and b) Missing mandibular second premolars with ankylosed and infra-occluded deciduous second molars in a distal malposition; (c-e) a ceramic onlay to close the residual mesial space

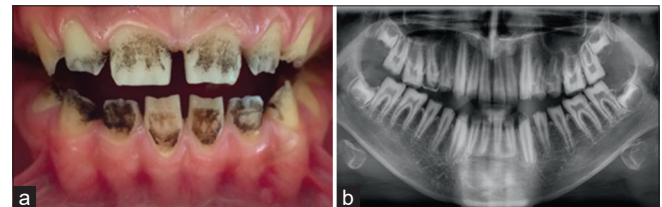


Figure 2: Pre-operative appearance. (a) Intraoral photograph. (b) Panoramic radiograph



Figure 3: Intraoral view after restorative treatment



Figure 4: Extensive crown

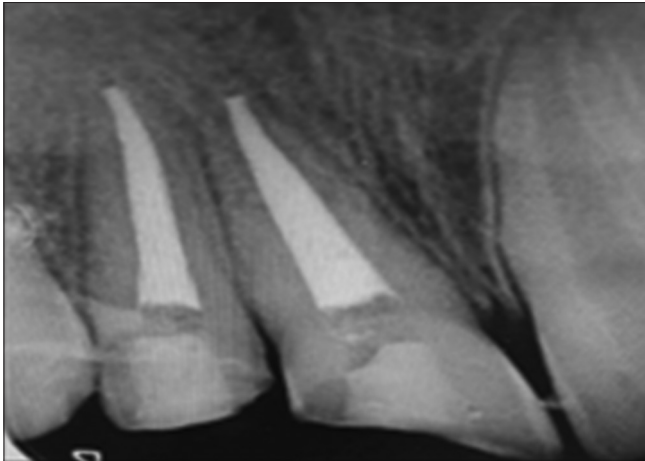


Figure 5: IOPA after root canal

the morphology and biomechanics of the teeth.^[10] The clinical management of this condition is very challenging for pediatric dentists with regard to the esthetic and functional rehabilitation and the patient's age and compliance. The use of the in-office CAD/CAM technology to treat amelogenesis imperfecta in a young patient yields satisfactory results.

Restorative treatment options can vary from requiring only oral hygiene instructions to extensive dental restorations that include composite fillings, ceramic veneers, metal-ceramic, or all-ceramic crowns (Figures 2 and 3).^[11]

Traumatic dental injuries (TDIs)

TDIs are a common occurrence in the pediatric population. More often than not, TDI involves the anterior teeth, of which the upper central incisors are more frequently affected. Advancements in dental materials and CAD/CAM systems have led to the ability to produce single all-ceramic crowns with high biocompatibility, esthetics, and optimal mechanical properties. The restoration process is non-traumatic to the patient and can usually be done in a single session. It is a new and improved way of treating extended dental trauma in children and adolescents involving anterior tooth fractures.^[12] Following is the case of TDI to 11 and 12 of an 11-year-old male patient (Figure 4). After completing the root canal treatment (Figure 5), the teeth were prepared supra gingival light chamfered finish line (0.5 mm) providing an adequate

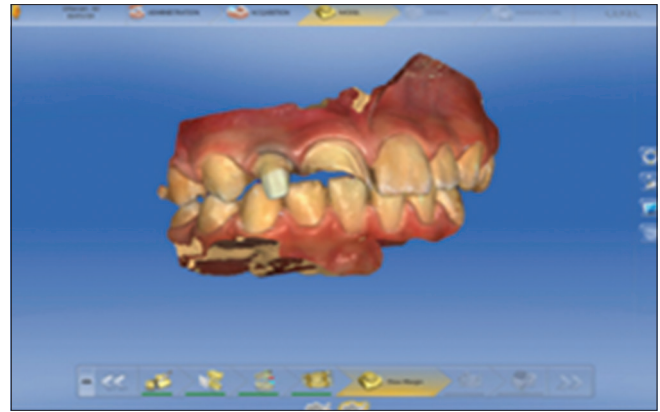


Figure 6: Intraoral scanner view of the mandible and maxilla



Figure 7: Post-operative view



Figure 8: Fractured central incisor

thickness for the restoration. The mandibular and maxillary arches were scanned after tooth preparation with an omnicam intraoral scanner (Figure 6). The restorations were designed using CERAC software. The restorations were fabricated using a milling unit and then cemented in the mouth (Figure 7).

Special care patients

Special care patients are defined as patients "whose medical, physical, psychological, or social situations make it necessary



Figure 9: Ceramic block machined



Figure 10: Computer-aided design/CAM partial crown bonded

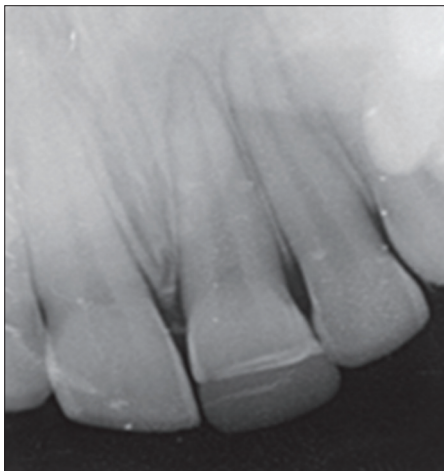


Figure 11: Post-operative radiograph

to modify normal dentistry routines to provide dental treatment for that individual.” Although it has been known for many decades that prosthodontics treatment makes a significant contribution to improving impaired oral health, treating special



Figure 12: Digital image design of the margin of the restoration

needs patients with prosthodontics is somewhat difficult as they often cannot be treated using “conventional” protocols of oral care. Difficulties of communication and consequences linked to their different situations (mental retardation, physical impairment, motor, visual, or hearing impairment) often make long chair-side oral care complicated. Moreover, when treatment has to take place, people with disabilities are more likely to have teeth removed than receive fillings, crowns, or bridges. CAD/CAM technology can help find prosthodontics and conservative solutions for a special care patient, in only one clinical session (Figures 8-11).^[13]

Esthetic treatment of severely decayed primary teeth

In today's time, there is a high demand among pediatric patients for esthetic restorations, as parents are aware, educated, and motivated to get the best treatment for their children. Due to this, in modern-day pediatric practice, esthetic treatment of severely decayed primary teeth is one of the greatest challenges for pediatric dentists. The use of esthetic restoration has become an indispensable aspect of pediatric dentistry. In the last decade, fabricating ceramic restorations with CAD/CAM has yielded significantly improved results. The improvements in digital impressions, software design, and cutting technique, alongside material improvement, have contributed to excellent clinical results. The right choice of the patient, the good marginal design, and the retraction of the tissues are important factors as they must be strictly followed in all restorative procedures (Figure 12).^[14,15]

The main advantages of manufacturing restorations with CAD/CAM technology are less clinical time in the dental office, fast production of the restoration, the classic methods of impressions are not necessary, the stable color of the ceramics, and excellent esthetic result (Figures 13-15).^[16,17]

As a disadvantage of these restorations, the high price may be mentioned, as well as the necessity of special education for the dentist, who works with the CAD/CAM system and the mandatory occlusal adjustment of the inlay.^[16]

3D Printed space maintainers

Bhaggyashri *et al.*, 2019 reported the fabrication of band and loop space maintainers using 3D printing technology. The



Figure 13: Digital image of digital restoration seated



Figure 14: Final occlusal view of the restored tooth



Figure 15: Twelve months following the examination

application of digital technology has resulted in decreasing human errors by automating the dental model fabricating process with three-dimensional printing.^[17] The innovative digital design of the 3D-printed space maintainer is precise, quick, and easy. The whole process of taking an impression of the patient, pouring the cast, digitalizing it; or directly taking an optical scan of the patient, then designing the space maintainer through CAD software and printing it with the help of a 3D printer greatly increases the precision of the appliance, minimizing human error. Furthermore, the appliance is printed as one unit, minimizing the breakage, thus reducing the failure of the appliance. Compared to a conventional appliance, a 3D-printed model has a more complex structure with a higher level of detail (Figures 16 and 17).

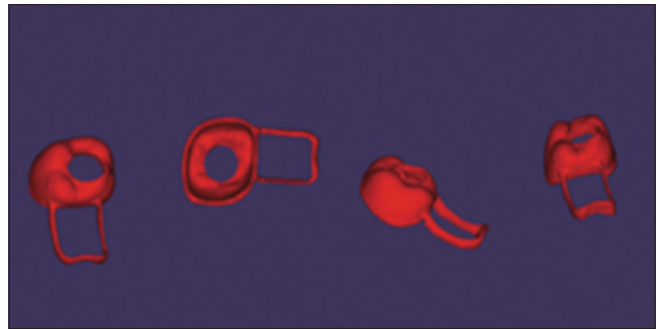


Figure 16: Digital design of the band and loop space maintainer on the dental computer-aided design 2.2 Valletta software

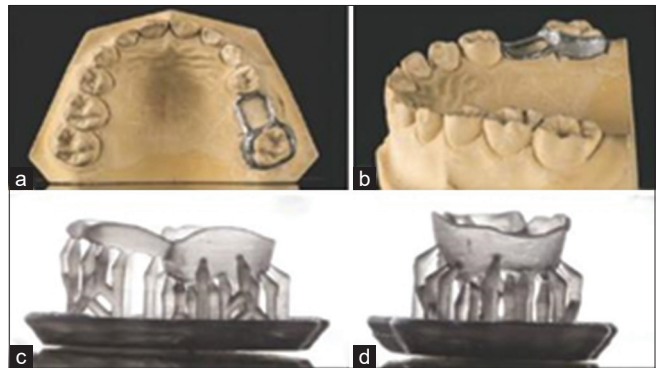


Figure 17: (a-d) Metallic three-dimensional-printed space maintainer

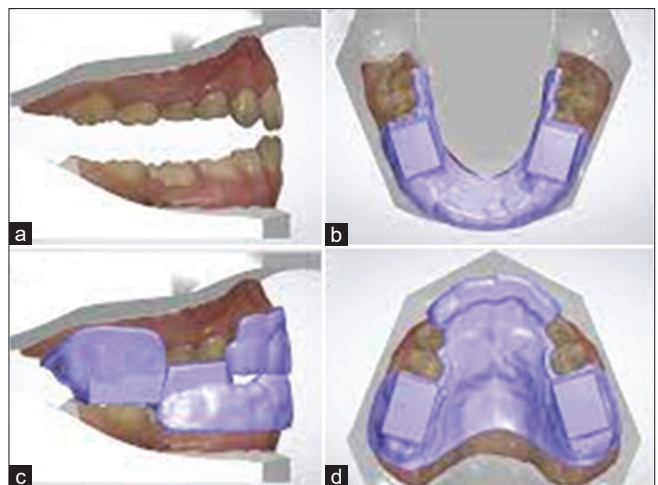


Figure 18: (a-d) Digital design of twin block

3D printed myofunctional appliance

In patients, who have not yet crossed the adolescent growth spurt, removable functional appliances such as activator, bionator, twin block, and frankel may be used. Al Mortadi *et al.*^[19] described a procedure for Andresen activator and sleep apnea appliance fabrication using computer-aided design and additive manufacturing technology. Al Mortadi *et al.* presented Hawley retainer manufacturing using intraoral scans obtained with TRIOS (3Shape, Copenhagen, Denmark), eliminating the need for conventional impression-taking and pouring plaster models. In clinical assessment of the retainer,

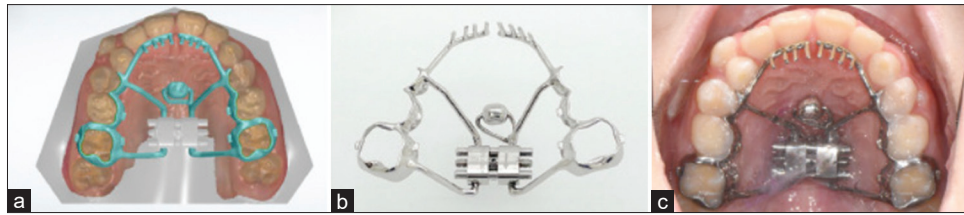


Figure 19: (a-c) Hyrax-Hayrake-blue-grass combination



Figure 20: (a-c) Hyrax-Halterman



Figure 21: (a and b) Optical scan of cleft palate patient

the authors concluded that the quality of the appliance was satisfactory.^[19]

It is very much possible to 3D print precise myofunctional appliances such as the Herbst appliance, the activator appliance, twin block appliances (Figure 18), blue grass appliance (Figure 19), and the hyrax appliance (Figure 20) for growing patients according to their needs. These precise myofunctional appliances can achieve excellent intraoral fit, leading to better patient compliance and treatment results. Other special appliances such as sleep apnea appliances, obturators, and feeding appliances for cleft lip and palate patients can also be 3D printed.^[20] Bioprinting of complex oral tissue structure scan helps study the biological response to forces induced by orthodontic treatment.^[21]

Autotransplantation

In tooth autotransplantation, 3D-printed templates help establish a guided atraumatic strategy. This could lead to fewer failures and a better outcome. A new method for tooth autotransplantation using three-dimensional (3D) surgical templates for guided osteotomy preparation and donor tooth insertion was illustrated in the literature. Vandekar *et al.* used 3D printing to scan and reproduce a diseased permanent maxillary central incisor. This quick prototype tooth replica was then used as a guide for determining socket size during surgical preparation at the recipient site. This enabled precise

positioning while protecting the periodontal ligament's life.^[21] A comparable method can be used with a 3D-printed surgical guide for future autotransplant surgery.^[22]

Digital workflow for NAM appliance therapy

Most digital workflows in NAM therapy to date apply optical surface scanning technologies to create a digital model, thereby making the process comfortable for newborn children with cleft lip and palate. A recent case report applied an intraoral scanner in a completely digital workflow for the fabrication of orthodontic appliances for CL/P patients (Figure 21).^[23] The authors suggested that the preheated scan head used was well tolerated by the patients, and they reported that clinically relevant areas of the palate were registered in <3 min of scanning. While intraoral scanners generally encounter difficulties in compiling images from edentulous spans, in the case report enough information was gathered to support compilation of the scanned images into a functional digital model. Considering the limitations of traditional impression techniques, some reports strongly recommend the use of intraoral scanners to render digital models of the cleft anatomy directly. Barriers to the widespread application of intraoral scanners in infants with clefts include the size of the scanner relative to the size of the infant's oral cavity. Digital models created through optical impressions are then used to design and manufacture various appliances by implying

CAD/CAM technology. This is the concluding step leading to the completion of the cycle of digital workflow in a dental practice. CAM by way of additive manufacturing also known as 3D printing has found many useful applications in pediatric dentistry. In the literature data, there is evidence about CAD/CAM technology usage in pediatric dentistry for dental restorations of extensive carious lesions, eroded and abraded teeth, primary teeth with an absence of a permanent successor, dental dysplasia or dental trauma of hard tooth tissues, for making of space maintainers and various other appliances used in interceptive orthodontics.

CONCLUSION

There is no denying the fact that conventional methods of practicing dentistry are soon becoming a thing of the past. Digitalization is percolating at a fast pace in every aspect of our practice and to ride this wave toward practicing dentistry in a modern manner, we need to keep ourselves abreast with the latest developments, devices, software, and technologies.

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