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# Digital Flow In Orthodontics And Pediatric Dentistry- A Systematic Review

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***Abstract:***
***Background****: The constant advance of digital technology is one of the most obvious examples of the innovations that dental professionals must incorporate and that can revolutionize the profession.The objective of this systematic review is to analyze and evaluate the benefits and impact of the implementation of digital flow in orthodontics and pediatric dentistry, evaluating the help of the different technological tools that the current era offers us.*
***Materials and Methods****: Electronic databases were searched; there were no restrictions regarding the language of publication. Studies had to have been published at least in 2019. Systematic and narrative reviews, clinical cases, analytical studies and case-control studies that investigated the influence of digital flow in orthodontics and pediatric dentistry were selected. The two principles were involved in the selection of studies, assessment of validity and data extraction. Disagreements were resolved by discussion.* (10)
***Results****: A total of 126 articles were obtained, of which 40 were selected according to the criteria described for this search. The studies demonstrated that digital flow in orthodontics and pediatric dentistry leads to better diagnosis, treatment planning and treatment especially in pediatric patients.*
***Conclusion:*** *The implementation of digital flow in orthodontics and pediatric dentistry induces benefits in daily dental practice, offering advantages in time, comfort and efficiency for both the patient and the dental staff.*
***Key Word:*** *Systematic Review; Orthodontics; Technology; Dental*

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## I. Introduction

The continued growth of digital technology is one of the clearest examples of the innovative changes that dental professionals must adopt that have the potential to transform the profession[1]. In recent years, the term "Digital Dentistry" (use of any technology controlled by a computer or artificial intelligence) has been frequently used among dental professionals to innovate procedures, techniques, and treatments to obtain better results than usual. in turn, justify the situation of traditional procedures.

Historically, Francois Duret, considered the "godfather of dentistry, " introduced in 1970 the first digitized approaches limited to image acquisition, planning, and digital machining through CAD/CAM. Currently, these digital workflows have been adopted by a wide range of disciplines[2], of which orthodontics and orthopedics have been one of the main ones to adopt the digital flow, because it requires careful analysis and large amounts of data to reach an accurate diagnosis and treatment plan.

One of the most desired results in dental practice, specifically pediatric, is to provide care in a friendly and stress-free manner. Orthopedic patients are exposed to several challenging procedures for professionals as they must deal with problems such as child behavior, gag reflexes, accidental aspiration of foreign bodies, and choking problems, among others[3]. In response to these drawbacks, a new approach called Digital Ortho Pediatric Dentistry (DOP Dentistry) has been introduced, which is the perfect integration between pediatric dentistry and pediatric orthodontics with technology[4].

The advent of digital tools has been a distinctive evolutionary milestone in the history of dentistry, offering great potential for use in clinical practice, with potential benefits for both the patient and the practitioner.

The advent of digital tools has been a distinctive evolutionary milestone in the history of dentistry, providing a great possibility of use in clinical practice, with potential benefits for both the patient and the practitioner. Therefore, the objective of this article is to analyze and evaluate the benefits and impact of implementing the use of digital flow in orthodontics and pediatric dentistry, that will help answer the population, intervention, comparison, and outcome (PICO) question was "Does the implementation of digital flow in orthodontics and pediatric dentistry induce benefits in daily dental practice?"

## II. Material And Methods

This systematic review is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).The first stage of this systematic review included the identification of elements to be evaluated, creating a PICO (P:paediatric patients undergoing orthodontic or paediatric dentistry treatment; I:patients in which the digital flow has been used for diagnosis, therapeutic plans and treatment;C: Digital flow or manual technique; O: Benefits and patient preferences) and formulating the research question: what are the long-term periodontal effects of mandibular fixed retainers?

Inclusion criteria were established as follows.
1. Type of study: Systematic reviews, narrative reviews, case-control, analytical studies, comparative studies, original articles, clinical trials and clinical case reports.
2. Articles published in the last five years
3. In any available language
4. Availability of abstracts and full text.

However, editorials, letters to the editor, and opinion articles were excluded.

The literature search was performed in several databases such as PubMed/MEDLINE, Scopus, Web of Science, Scielo, Cochrane, Springer, and Researchgate. The last search was performed on October 24, 2023 for all databases, without any language filter. The search formula for articles of importance was carried out using combinations of keywords such as: “Digital orthodontics” “Digital dentistry” “Digital flow orthodontics” “Digital Dental Models” “Digital flow in paediatric dentistry” “3D orthodontic” “Modern digital paediatric dentistry” “Digital diagnosis” “Digital paediatric dentistry”. Studies published from January 1, 2019, to September 31, 2023 were selected.

Appraisal of research for inclusion in the review, assessment of validity and data extraction were conducted independently and in duplicate by two authors who were not blinded to the authors or the research results. Disagreements were resolved by discussion.

Data extraction was performed independently and in duplicate by two reviewers. Extracted data included information on authors, year of publication, study design, objectives, results, and main conclusions. A standardised data extraction format was used to ensure consistency and completeness of the information collected.

## III. Result

Initially, more than 120 articles were found in different electronic databases. After reviewing the titles and syntheses of these articles, 35 were considered relevant for inclusion in the current systematic review article. (Figure1.)

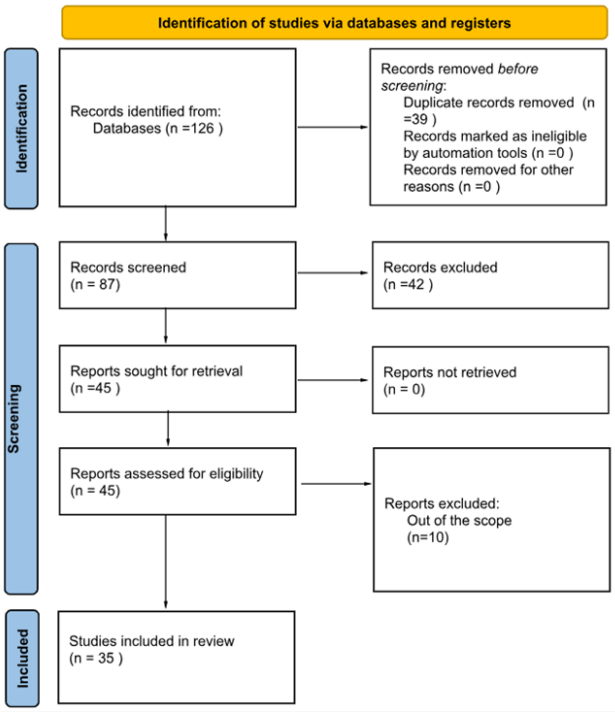


**Figure 1.** Prisma 2020 Flowchart representing the study selections process.

The results evaluated are related to: Patient preferences as well as the description of the benefits of using the digital flow in different areas such as diagnosis, treatment plan and treatment itself. In addition, some additional important points were pointed out such as the relationship between the digital flow and education.

***Diagnosis***

***Artificial Intelligence***

AI (artificial intelligence) is gaining significant importance in society, particularly in dentistry. It enhances diagnostic accuracy, predicts outcomes, and aids clinical decision-making by analysing large datasets. AI reduces errors in diagnosis and treatment and utilises techniques like convolutional and artificial neural networks for precise landmark detection, fast digital cephalometric analysis, and treatment predictions[5]. As artificial intelligence technology is incorporated into clinical practice and orthodontic workflows, it is important to evaluate and monitor the quality and safety of AI algorithms. However, the increase in the number of algorithms available and the different ways in which they can affect clinical workflows adds complexity to their implementation[6].

The Automated Landmark Identification Method for CBCT (ALICBCT) is a tool that has been explored and implemented as an extension of the three-dimensional (3D) Slicer platform. This algorithm is a robust automatic identification tool used in both clinical and research settings. Its implementation allows for continuous updates to achieve greater precision in the accurate and efficient placement of landmarks on different craniofacial structures. The use of AI in this process benefits both oral research and clinical aspects[6].

***Use of CBCT***

Orthodontic diagnosis is shifting from two-dimensional (2D) to 3D measurements, thanks to maxillofacial cone beam x-ray computed tomography (CBCT), which improves diagnostic accuracy. This technology is expected to create new methods for determining optimal occlusion based on each patient's jaw shape and function. However, during the transition, it's essential to link 3D data with traditional 2D methods like lateral cephalograms for evaluating skeletal and dental relationships. CBCT-based cephalometric analysis has shown lower inter-operator variability compared to conventional cephalograms[7].

***Stereophotography***

The results were similar to those obtained with Bellus3D, taking into account that the learning curve in Ceph 3D is deeper, given the knowledge required to handle the different software.In orthodontics and orthopaedics, interpreting soft tissue morphology and position is crucial for accurate diagnosis. 3D assessments enable unlimited projections for facial analysis, helping predict both aesthetic and functional outcomes. True Depth technology offers a cost-effective and ergonomic alternative. M. Beretta, F. Federici Canova, L.Zaffarano, and A.Gianolio highlight smartphone applications like Bellus3D, which can overlay facial and intraoral scans. Another option is Ceph 3D, which combines multiple software tools for processing and viewing files, though it has a steeper learning curve compared to Bellus3D. Both approaches produce similar results[8]. Three-dimensional digital facial photographs taken by scanners such as the Bellus3D Face Camera Pro and the 3dMD face system have clinically acceptable veracity for diagnosis and treatment planning. According to studies, its accuracy has also been found to show good scan repeatability[9].

***Intraoral Scanner-Manual vs Digital Technique***

It was Charles Hull who introduced the first three-dimensional technology in 1986 based on CAD models[10]. Three-dimensional impressions aim to accurately replicate teeth and surrounding tissues, enhancing diagnosis, planning, and treatment. Despite some limitations due to data acquisition and image processing errors, they offer significant benefits over traditional methods, particularly in paediatric care. These advantages include reduced work time, improved patient preference, and greater model precision. Regarding work time, Francesco D-Ambrosio and others[11], state that digital impressions can scan areas that remain unfinished, allowing feedback in real-time, which reduces work time; An important point is unlike an error produced in a traditional impression which only becomes visible after the casting material has hardened. Additionally, with the intraoral scanner, the operator can immediately work on the captured image, completely avoiding traditional cleaning, disinfection, and casting procedures. It also reduces time when sending and sharing with different colleagues and laboratories for making decisions about the treatment. Mariana Francesca Sfondrini, Paola Gandini, and collaborators[12] ,demonstrated significantly shorter chair time and processing times than alginate impressions.

Regarding patient preferences,Hakan Yimaz, Merve Nur Aydin[13]. demonstrated in their study that paediatric patients mostly opt for digital impressions for greater comfort, which improves the experience of these patients contributing to better behavioural management.In terms of time there was no significant difference compared to manual.Another additional feature that digital scans offer is segment printing which helps with non-compliant and difficult to manage paediatric patients[14]. A recent study shows important figures in the compliance

of paediatric patients, with 51% of children opting for intraoral scanners, 29% conventional, and 20% without preference. A reported 3.6% of children feel stressed with digital processes compared to 89.3% with conventional methods[15]. Regarding precision, some drawbacks modify the precision of the models, for example in manual impressions, there are bubbles in cracks and marginal ridges, as well as incomplete alginate flow and detachment from the tray, on the other hand, a probable Limitation in digital impressions is the size of the scanner head (it may be difficult to reach posterior areas in paediatric patients[16]. Rahma ElNaghy and collaborators[17] ,evaluate the accuracy of 3D impressions in babies with cleft lip and palate, culminating their work with the recommendation of using 3D methods as an alternative to traditional impressions since, in addition to overcoming challenges and complications in patient management, reduce the burden of care on both patients' families and care providers. Gurav Gupta and collaborators support the use of 3D analysis with their study of manufacturing Zirconia crowns in which they conclude that intraoral scanning eliminates disadvantages of manual methods such as the difficulty of adjusting the crown, the impossibility of trimming excesses and making occlusal adjustments easily[18].

Yasaman Etemand-Shahidi et al.[19] support the use of 3D printing especially as orthodontic models, however, they highlight that some factors such as layer thickness, base design post-processing, and storage can alter the accuracy of the models. Wyatt A. Loflin and collaborators[20] ,specifically analysed the effect of the impression layer in the evaluation of 3D printed orthodontic models using traditional orthodontic plaster models as a criterion standard. They concluded that the 100um layer height models show a greater correlation with standard orthodontic stone models and a reduction in impression times, which is why they have been chosen and recommended as potentially clinically acceptable for evaluating treatment results.

Despite the advantages of digital impressions, they haven't fully replaced manual methods in daily dental practice. Sabina Saccomanno and Stefano Saran's study[21] found that the choice of impression technique depends on the type of orthodontic therapy and devices. Digital impressions are more commonly used for personalised therapies, such as aligners, typically preferred by adults, while conventional impressions are still dominant for fixed devices. The limited adoption of 3D impressions is due to the high cost of intraoral scanners and the steep learning curve required to use them.

***Planning and Treatment***

***Software***

The digital revolution in orthodontics requires specialised hardware and software to manage Standard Tessellation language (STL) models and other digital files. Some software is proprietary, while others are open-source. Notable open-source programs include Blue Sky Plan, MeshMixer, ViewBox, and Blender.

Blue Sky Plan offers useful modules for visualisation, orthodontics, and guided surgery, with most features available for free.

MeshMixer: allows 3D object creation, mesh repair, simulating and evaluating the patient's occlusion (virtual model); similar to surgical preparation; orthodontic band design; design any other prosthetic or orthodontic structure but can be challenging for those with limited computer skills.

ViewBox: provides free access to native tools, though some have a 30-second limit, and is effective for model analysis and preparation.

Blender: is widely used for 3D editing but is complex in its original version.

While open-source software has low operating costs, it often comes with a steeper learning curve, though free tutorials are available to help users automate processes and save time[22].

***3D Reconstruction and Impressions***

The benefits of 3D printing stand out mainly in the following areas: 1. 3D images with greater precision and similarity to reality. 2. 3D technology has a great utility in the communication between professionals and professionals with patients. 3. Intraoral and extraoral 3D images can be used to enrich and expand research in dentistry. 4. Reduce patient discomfort. 5. Operative time and steps are considerably reduced. 6. Images can be stored in digital format. 7. Avoids deformation of the impression material and plaster model while ensuring authenticity and accuracy of the scanner[23]. 3D printing technology has become an agile method to generate prototypes that has gained relevance in recent times. There are several techniques for 3D printing one of the stars is Stereolithography uses the photopolymerization method with the help of an ultraviolet laser, another technique is Selective Laser Melting which uses a high density laser and the Polyjet method is a method that uses matrix type print heads that moves in horizontal and vertical direction and there is a roller that flattens the surface layer of resin[24].

***Digital Flow and Education***

The introduction of digital technology in orthodontics has improved the experience for both the patient and the clinician. There is knowledge, attitude and practice of digital orthodontics among orthodontists. Students are aware of the availability of digital orthodontics and have a positive attitude toward its incorporation into their

routine practice. However, there is a lack of practice in digital orthodontics, as although orthodontists have adequate knowledge and a positive attitude towards it, they do not apply it daily in their practice[25].

***Other applications of digital technology in orthodontics and paediatric dentistry***

***Aligners in orthodontics***

Clear aligner systems have been in orthodontics for years and offer several advantages over traditional braces, including better aesthetics, less pain, reduced office time, and fewer emergencies. They may shorten treatment time for mild to moderate cases without extractions, but there's no clear consensus on their impact on oral hygiene, with minimal differences in plaque and enamel lesions. However, concerns remain about the systemic effects of aligners, particularly the potential toxicity of 3D resins used in these devices. More research is needed, especially regarding their impact on fertility in young patients, a key user group[26].

One of the primary objectives of orthodontic treatment during the mixed dentition phase is to expand the maxillary arch to facilitate proper tooth alignment and rectify both sagittal and vertical malocclusions. The Invisalign First® system (Align Technology, Santa Clara, CA, USA) has been identified as an effective option for growing children requiring maxillary arch development. Research conducted by Gonçalves A et al. demonstrated that the Invisalign First® system can enhance arch width with an efficacy comparable to that of traditional removable appliances used for maxillary expansion. However, it is noted that both Invisalign First® aligners and conventional removable expanders are less effective than cemented appliances in achieving these outcomes[27].

## IV. Discussion

This study highlights that technology serves as a valuable tool in the planning and implementation of treatments, particularly within orthodontics and orthopaedics. Mayma Natasha M et al.[28] , support this assertion, concluding that Digital Flow not only reduces working time but also enables the creation of complex appliances with high precision. The advantages of this technology benefit both patients and practitioners. It provides 3D images, impressions, virtual settings, and photographs, which, when combined with thorough professional preparation, enhances the integration of treatment elements. This approach enhances communication with patients and other professionals. In children, the use of technology has proven beneficial in terms of both comfort and treatment efficacy. However, the integration of new technologies in the care of young patients has been slow, with few clinical trials available. Abdulrahman A. et al. indicate that while the quality of 3D printing is improving and gaining popularity in dentistry, there is a pressing need for long-term clinical studies to establish standards and ensure the safe implementation of 3D printing in dental practice[29]. According to the patient's expectations and satisfaction, the use of intraoral scanning can help the patient and operator to determine aspects and make decisions more accurately. It also presents several utilities in the area of orthodontics and orthopaedics such as: Expanders: these appliances can be laser synthesised directly from STL files providing individualised "bands"; functional appliances; aligner systems; labial appliances[30]. Taís de Morais Alves da Cunha, Inessa de Silva Barbosa, Karolinne Kaila Palma, support this idea with their research having as conclusion that indirect cementation, virtual extraction of brackets decrease treatment time in orthodontics, eliminate clinical and laboratory steps favouring greater patient comfort, greater accuracy and predictability, highlighting that a possible limitation to adopt CAD/CAM systems in daily practice is the economic cost and the need for professional training[31]. Additive manufacturing, also known as 3D printing, a tool used for diagnosis and treatment in our area, replaces materials with digital data through the CAD/CAM workflow. Andrea Scribante, et al, in their review highlight the potential of digital workflow in dentistry, which encompasses the use of 3D printing. They evince several advantages such as accuracy, patient comfort, shorter times and reduced environmental costs. On the contrary, some disadvantages are still related to this technology (costs, longer learning curve, referral to specific technical laboratories and health risks)[32]. Research, including a study by Luqmani et al.[33], indicates a strong patient preference for intraoral scanning over conventional plaster models, with 91% of participants favouring the digital method. Vincenzo Ronsivalle and colleagues highlighted that digital technologies enhance data collection, communication, and the creation of customised devices. However, they emphasised that transitioning from analog to digital requires time and consideration of the learning curve associated with practitioners' expertise. Despite these challenges, investing in digital technologies promotes a more efficient, modern, and patient-friendly workflow in dental practices[34]. Currently, an interactive 3D treatment plan can now be developed using digital models, enabling virtual setups and assisted bracket positioning. A study by Paolo Albertini et al. found that three evaluated digital bracket positioning systems were equally accurate, with no statistically superior option. The advantages of these technologies for orthodontists include diagnostic setups, virtual extraction simulations, and computer-assisted cementation. Additionally, digital models require less storage space compared to plaster models and allow for three-dimensional analysis of tooth movements in multidisciplinary cases, providing numerous benefits to modern orthodontic practice[35]. (10)

## V. Conclusion

It is concluded that the implementation of a digital flow in orthodontics and paediatric dentistry enhances daily practice by improving communication among patients, dentists, and technicians. It facilitates better diagnosis, guides patient decisions regarding treatment acceptance, and increases the comfort of paediatric patients. The use of CBCT improves diagnostic accuracy and enables 3D cephalometry. Stereophotogrammetry aids in extraoral diagnosis and predicts aesthetic and functional outcomes. Intraoral scanning is ideal for paediatric patients, reducing overall working time. Modern open-source dental software, though requiring a steeper learning curve, allows for model modification and treatment adjustments. Furthermore, digital impressions ensure the authenticity and accuracy of scans, leading to greater realism in treatment planning.

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