Un estudio comparativo para evaluar el proceso sustractivo y aditivo en odontología: una revisión sistemática

A comparative Study to Evaluate the Subtractive and Additive Process in Dentistry: A Systematic Review

Ana M. Carreño [1]
Margy E. Torres [2]
Marlon S. Ramírez[3]
Jairo Núñez[4]

[1] *Universidad Pontificia Bolivariana, Bucaramanga, Colombia.*
Email: ana.carreno.2014@upb.edu.co

[2] *Universidad Pontificia Bolivariana, Bucaramanga, Colombia.*
Email: margy.torres.2016@upb.edu.co

[3] *Universidad Pontificia Bolivariana, Bucaramanga, Colombia.*
Email: marlon.ramirez.2016@upb.edu.co

[4] Universidad Pontificia Bolivariana, Bucaramanga, Colombia.
Email: jairo.nunez@upb.edu.co

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Resumen. El objetivo de este estudio es realizar un análisis sobre los principales aportes de la manufactura aditiva en piezas dentales y los beneficios de este procedimiento en la odontología, así como establecer las ventajas y limitaciones que esta modalidad conlleva. La investigación se basó en una revisión sistemática con adaptabilidad a la metodología Prisma y Tranfield, enfocada en el impacto de la manufactura aditiva en las clínicas dentales y en los clientes que adquieren las piezas en términos de gusto y adherencia al producto, así mismo, en términos de contribución al conocimiento. Este estudio queda como precedente para otras investigaciones que se realicen sobre este tema. Fueron revisados artículos publicados en los últimos cinco años en las bases de datos Scopus y Web of Science. El proceso se desarrolló a través de criterios de inclusión y exclusión, se revisaron criterios de instancia final como material, tipo de impresión y post-procesamiento, se aplicó un filtro final resultando así los artículos para revisión de la literatura. Este proyecto contribuye al conocimiento de los procesos realizados en la fabricación aditiva para piezas dentales, las ventajas y desventajas, dejando así un precedente para la adhesión de las clínicas dentales a este método.

Palabras Clave. Additive manufacturing; 3D print; dentistry; teeth; dental pieces.

Abstract. The objective of this study is conducting an analysis on the main contributions of additive manufacturing in dental pieces and the benefits of this procedure in dentistry, as well as establishing the advantages and limitations this modality involves. The research was based on a systematic review with adaptability to Prisma and Tranfield methodology, focused on the impact of additive manufacturing in dental clinics and in the clients who acquire the pieces in terms of taste and adherence to product, likewise, in terms of contribution to knowledge. This study remains as a precedent for other investigations to be conducted on this topic. Articles published in the last five years from the Scopus and Web of Science databases were reviewed. The process was developed through inclusion and exclusion criteria, final-instance-criteria such as material, type of printing, and post-processing were reviewed, a final filter was applied thus resulting the articles for review of the literature. This project contributes to the knowledge of the processes performed in additive manufacturing for dental pieces, the advantages and disadvantages, thus leaving a precedent for the adherence of dental clinics to this method.

Keywords. Additive Manufacturing; 3D Print; Dentistry; Teeth; Dental Pieces.

I. Introducción

This study emphasizes the interest from the professional and academic approach on the processes performed in dentistry in dental pieces, specifically with the adhesion of additive manufacturing as a modality that allows dental professionals and clinics to have greater precision, quality, save time and reduce costs.

Additive manufacturing or 3D printing in dentistry involves two aspects to consider; the application of both Computer Aided Design (CAD) and Computer Assisted Manufacturing (CAM) [1], which have significantly advanced during the last decades, as well, have led to the development of new types of materials, digitization, and automation of various work processes.

These processes have provided comfort and better quality of restoration to dental professionals, likewise, restorations that are produced through rapid prototyping are more adaptable and faster to produce [2], [3] compared to those generated through the subtractive or traditional modality.

For greater contextualization, additive manufacturing is a technique that is responsible for digitized production, allowing manufacturing different objects, which have previously been modeled [4]. This procedure is performed layer by layer of material until a three-dimensional object is formed [5]. Each of these layers is printed directly on the previous one according to a computer program; therefore, it is possible to create implants in a personalized with shorter time and lower cost than any other technique [6]. In this sense, according to Fragoso [7] additive manufacturing is the technique that allows creating a solid three-dimensional object from a digital model, with the aid of digital reading and interpretation equipment.

In subtractive manufacturing, with traditional cutting, for the manufacture of dental pieces in implants, metallic material is used through machining techniques, therefore, a piece or implant is conceived from the elimination of material, either by chip removal or by abrasion, as described by González and Quenard [5], in their article on additive impression in metallic implants:

The machining by chip removal consists of a tool with several blades that in several passes separates chips from the material, through roughing processes, where a lot of material is removed with relative precision, and finishing processes, where a smaller amount of material with higher precision. On the other hand, in abrasion machining, an abrasive wheel is used that is responsible for progressively wearing the material, detaching material particles.

The trends suggest that processes performed through subtractive manufacturing tend to be replaced by additive manufacturing [8], because of computer automation in each of its phases, which leads to greater precision and attention to detail. While carving by hand or the operation of a lathe, a drill or a saw, is called subtractive manufacturing [9]; automated processes that involve technology are called additive manufacturing.

The present study is a systematic review with the Prima and Tranfield methodology, analyzing articles in order to make a comparison of the subtractive and additive process in dental pieces. The critical factors in the modalities of implementation of the manufacture of this procedure are identified, as well as the used technologies, the advantages and disadvantages this type of manufacturing involves.

The trends that additive manufacturing represents are significant, because it is a type of manufacturing present in different fields and with ecological technology [10], according to Frank Carsten, founder of Concept Laser GmbH and manager of HZG Management GmbH, says that Whoever does not adopt additive manufacturing or begins to do so, will lose in competitiveness.

A study at the University of Colorado in the United States about 3D printing with polymers, reports that recent growth of this type of printing has been extensive and the space of various platform technologies to spread their prototype production models is essential to achieve high growth rates and on a recurring basis [1]. Therefore, the change to the production of workpieces depends on the adaptation of materials [11] providing precision in the design and physical and mechanical properties for its application.

According to a study published in the metalworking journal Interempresas, additive manufacturing is conceived as a type of ecological technology alternative to previous manufacturing strategies, in an increasingly disruptive way [10]. It is often a matter of replacing classical techniques such as casting or milling. This moldless process expands geometric freedom, reengineering, and resource preservation, with great advantages in economy and availability [10]. According to that has been previously stated, considering the spatial and geographical delimitation of this study, publications, articles and projects on subtractive and additive manufacturing in dental pieces will be consulted. Primary information related to the subject of this research will be obtained from different parts of the world and being focused on dental pieces.

In context with the current situation of dental technology, it can be said that this industry conducts its processes in a conventional way [9], which implies high material costs and in salary terms.

There are fixed prices for dental prostheses, so profitability is minimal, therefore, dental technicians choose cheap materials or purchase implants abroad [12]. On the contrary, with additive manufacturing, dental prostheses such as multiple crowns or bridges are obtained with specific geometries for each patient in the construction space of a laser fusion equipment for metals. Which is much more economical and efficient, from 80 to 100 implants simultaneously [13], then, dental prosthetics laboratories tend to become impression centers, this means a great leap in terms of profitability. It can be considered that dental prostheses, with all volumes, can be 60% to 70% cheaper than solutions made by hand [10]; hence the importance of additive manufacturing in the dental sector.

For the dental sector, this study contributes to identify the advantages and disadvantages we could find for the processes in additive and subtractive manufacturing in dental pieces, in order to know the method that contains benefits for its elaboration; also, for the university the contribution focuses on the investigative aspect of this type of manufacturing.

From the above mentioned, we pose some questions that account for the process conducted in this article:

What are the trends in research studies on subtractive and additive manufacturing in dental pieces in the publications of the last five years by country, author and journal? What are the most influential research articles found in the literature review based on global citations and journal rankings on subtractive and additive manufacturing topics in teeth? What are the most commonly used materials in the dental impression process? What are the printers or types of impressions used in the additive process of teeth? What are the advantages and benefits of printing from the use of 3D printing? What is the input data associated with the design, materials and processes of the tooth in additive impression?

From the related questions, it is intended to give an answer with the development of what is presented here in the following.

The following information comes from interviews with two dental laboratory professionals, dedicated to the manufacture of dental pieces, one of them in additive manufacturing and the other in subtractive or traditional. Each of the steps to develop the teeth becomes evident according to the needs of the patients.

A. Subtractive manufacturing process

1. Impression taking with trays in the office.
2. Disinfection of the material.
3. Send the preliminary impression to the laboratory.
4. Disinfection of the material.
5. Diagnosis of preliminary impression.
6. Start of procedure.

Elaboration of total, removable prosthesis, acrylate of structures:

6.1.1. Receive the preliminary model.

6.1.2. Send a preliminary model with an individual tray to the office.

6.1.3. Collect definitive impression.

6.1.4. Send line for teeth test.

6.1.5. Collect teeth test.

6.1.6. Send part to the dentist to be delivered to the patient.

Manufacture of fixed prostheses

6.2.1. Collect definitive impression.

6.2.2. Submit metal test.

6.2.3. Collect metal proof.

6.2.4 Send ceramic metal test.

6.2.5 Collect Metal Ceramic Test.

6.2.6. Send part to the dentist to be delivered to the patient.

Elaboration of a temporary in thermo-cured

6.3.1. Collect definitive impression.

6.3.2. Tooth waxing.

6.3.3. Muffle.

6.3.4 Press.

6.3.5 Polish.

6.3.6. Ends.

6.3.7. Send part to the dentist to be delivered to the patient.

Manufacture of retainer, temporary thermo-curing car, individual trays, cover and plates.

6.4.1. Collect definitive impression.

6.4.2. The tooth is made.

6.4.3. Send part to the dentist to be delivered to the patient.

B. Additive manufacturing process

1. Impression taking with trays in the office.
2. Disinfection of the material.
3. Send preliminary impression taking.
4. Make final model.
5. Perform print diagnostics.
6. Request antagonist model in articulator.
7. Request work orders.
8. Register patient data in the system.
9. Register type of restoration and tooth.
10. Scan model.
11. Die on the system.
12. Enter terminal line in the system.
13. Indicates restoration parameters.
14. Throw preliminary model.
15. Perform machining.
16. Send part to the dentist to be delivered to the patient.

C. Advantages and disadvantages

Additive manufacturing allows creating a solid three-dimensional object from a digital model, with the aid of digital reading and interpretation equipment. While subtractive manufacturing processes involve techniques such as milling and turning, a block of material is cut into the desired shape, more material and time is spent [7]. 3D printing seeks to manufacture different objects, which previously modeled; this procedure is performed layer by layer of material until a three-dimensional object is formed, reducing costs by using an easy-to-find material. However, these models do not always offer security when used for certain tasks, for example, for plastic parts frequently model prototypes tend to break when force is applied on them, gets deformed if they are exposed to high temperatures and even the finish of the parts is not always favorable when mechanical interactions are performed between them [5]. There are also small errors that can occur in the model and, when trying to correct them, the functionality of the model is endangered.

According to Zahera [14], in additive manufacturing, products involving great difficulty, because of their characteristics and the way they are conceived, are more manageable without cost increases. While complex geometry tends to suppose a cost increase for traditional processes (subtractive or conformative), when additive manufacturing is applied, it can even suppose a simplification, in addition, the adaptation of the forms to human biomechanics. Therefore the designs provide better interaction with users without necessarily affecting manufacturing costs (ergonomics, customization), which provides clear applications for the medical health sector.

A disadvantage in subtractive manufacturing is the roughing of material or cutting from a CAD file that was initially 2D (two-dimensional) and later the 3D CAD files were integrated [15]. Some examples of these technologies are milling machines (CNC router), CNC lathes, CNC machining centers, laser, water and plasma cutting, among others.

In the health sector, it offers benefits in terms of planning surgeries by using precise anatomical models, the development of orthopedic implants and prostheses adapted to the specific needs and dimensions of the patient, use of 3D printed human parts [5], printing of living tissues to perform trials related to the development of new medicines, among other advantages.

In general medical implants, metallic materials are normally used, numerous techniques were established to improve the integration of these implants in the human body. Additive manufacturing methods [16], has allowed the rapid manufacture of parts having greater geometric complexity, providing the possibility of easily making modifications to the design. The variety of 3D printing technologies also makes possible to obtain parts from different materials.

In subtractive manufacturing, for the manufacture of dental pieces in implants, metallic material is used through machining techniques, therefore, a piece or implant is conceived from the elimination of material, either by chip removal or by abrasion [16], where an abrasive wheel is used that is responsible for progressively wearing material, releasing particles, which is considered as a disadvantage.

II. Background

In the article "Additive Manufacturing", considered as a contribution from studies conducted on this subject, the results of research on the field of additive manufacturing are presented [5]. A process performed by using the method of cast extrusion, where the versatility of this technology is demonstrated, as well as the high potential for contributing to the innovation of the manufacturing industry.

The research shows that this type of process consists of a method performed through digitized production processes, intended to generate prototypes from models designed for a subsequent manufacturing of different objects. Since previous modeling is performed, the product has high precision [5], [16], because this procedure is performed layer by layer of material until a three-dimensional object is formed, which minimizes material waste.

The research project called "Development of a 3d additive manufacturing process for the application of metals" [7] aimed to show the steps performed in the layer-by-layer material depositing process conducted by the author by using metal. Concluding that this system is low-cost compared to other manufacturing modalities, also showing the advantages of this process with respect to conventional manufacturing such as the use of manual lathes and milling cutters.

An article published in Chile, about the surgical management of mandibular tumor assisted with 3D printing technology, stated that these models "are an effective tool in the planning of mandibular resections for tumor pathology, they are not only used for treatment planning and for the production of individualized hardware, but they are also an aid for patient education" [17]. Improving diagnostic quality and could even be used in preoperative simulation.

A study on the use of a JIG (neuromuscular deprogramming self-induced physiological centric relationship registration technique) to determine the position of dental implants in 3D printed models, in order to correct the position of the implants dental models in a 3D printed model and compare its precision with dental models obtained by conventional impression [18]. It was established that the use of the technique has greater differences compared to conventional impressions.

These processes have become a technique with many advantages such as reducing time for creating models, great availability of 3D printing equipment, reduction of costs by using an easy-to-find material, among others [7]. However, these models created in additive manufacturing do not always offer safety when used for certain tasks, for example for plastic parts, some times model prototypes tend to break when force is applied, deform if they are exposed to high temperatures and even the finish of the pieces is not always favorable when mechanical interactions are performed between them [7]. In addition, there are small errors that may exist in the model and, when trying to correct them compromises the functionality of model.

In the article "additive manufacturing, advanced technology for the design and development of products", presented at the XVI International Congress of Project Engineering, the author [14] identifies the most important aspects of additive manufacturing processes. From the fundamental concepts for understanding this type of technology, to the advantages over conventional manufacturing processes, it also denotes the challenges that must be overcome for this type of process has acceptance in various sectors. In this research, the author mentions that this type of manufacturing procedure by controlled disposition of the inputs or raw material, layer by layer, in a way that material is not wasted because it is provided exclusively where it is relevant, until achieving the geometry end that had been designed. Therefore, there are great possibilities that favor the different manufacturing processes, which allows the development of products and parts of all kinds with applications in all sectors.

In the research "Design project of a prosthesis from additive manufacturing (3D printing)" [19], a prosthesis prototype is made based on additive manufacturing processes, where the aim is to identify a procedure that can be substitute, inexpensive and easily accessible compared to conventional processes that develop prostheses. A study is conducted on the prostheses that are currently used to know the technical requirements, after which the design is proposed in accordance with previous studies, in such a way that the product can be manufactured using a 3D printer. One of the purposes of the project is the design of a prototype that is in accordance with the specifications of the human body, in such a way that it helps mobility and make easier the life of people.

The research "Additive Digital Manufacturing Technologies, advantages for the construction of models, prototypes and short series in the product design process" [15] shows the inherent aspects of manufacturing with digital technologies. The relevance of this type of process, since it allows a prototype to be materialized with a design and conceived in a digital file, where it is ready for its manufacture using a wide range of materials and finishes, therefore, the article shows characteristics, advantages and opportunities offered by this type of technology for the manufacture of various products.

The study performs an analysis of additive digital manufacturing technologies, as fundamental for manufacturing procedures because it offers advantages such as direct manufacturing in shorter times, generation of complex geometric shapes with high precision [15], integration of various materials in a single process and a paradigm shift with respect to manufacturing processes where material waste is minimal.

The article "Manufacturing processes with 3D technology" describes the various types of 3D printers that are currently on the market, it also details the principle of operation of each of them in accordance with international standards. The types of additive manufacturing referred by the author are binder injection, direct energy deposition, material extrusion, material injection, powder bed fusion, sheet lamination and photopolymerization. The author also refers to the difference between a 3D printer and machining through a CNC machine tool [20]. Consequently, research work is related to this article in the sense of the study of additive technology, its advantages compared to conventional manufacturing methods.

III. Literature Review

A. Additive and subtractive manufacturing

The types of production and the modalities of product manufacturing along with technology advance, in terms of precision and durability, in addition to the inherent costs, have led to the emergence of processes that are alternative and can contribute to improving the quality of products; an example of this is additive manufacturing. According to Ulrich & Eppinger [21] in 1983, a stereolithography technique was developed, generated by Charles Hull, this fact constitutes a relevant event in manufacturing processes, since it was the first additive digital manufacturing technology, founding the bases of a new type of manufacturing modality. Thus, allowing generating physical objects directly from a file digital and through the addition of successive layers of material and not subtractive as traditional technologies did [21, p. 289]. This allows them to build complex geometries, to manufacture polymeric parts without the need for molds, among other advantages.

Therefore, with this new set of modalities that have emerged in recent times in manufacturing processes, additive manufacturing stands out over subtractive. Other author has defined this technology as a set of technologies that uses 3D digital design, which is transformed into a real object, by means of the union of material in layers in a controlled way by means of a computer [22]. Subtractive manufacturing is one in which pieces of material are eliminated from a compact block until the desired product.

Along the same lines, Fragoso states that additive manufacturing is the technique that allows creating a solid three-dimensional object from a digital model, with the help of digital reading and interpretation equipment. Likewise, it states that this type of modality is different from traditional manufacturing processes, because in processes that involve techniques such as milling and turning, a block of material is cut until the desired shape is obtained [7]. From the initial matter, this type of procedure requires an adjusted dimension of the material that is used, it must also have a specific shape and stipulated size, since the necessary material will be removed, it is also important to point out that in this type of traditional processes the shapes and sizes are restricted.

Another argument on this subject states that additive manufacturing or 3D printing is a technique or method that is responsible for digitized production, where it is sought to manufacture various objects, which have previously been modeled. This procedure is performed layer by layer of material until a three-dimensional object is formed [5]. This process has become a technique with many advantages such as reduction of time in the creation of models, availability of 3D printing equipment, reduction of costs derived from the use of easy-to-find materials, among others. However, the models created in additive manufacturing do not always offer safety when used for certain tasks, this in the case for example of plastic parts, where many times the model prototypes tend to break when force is applied, deform if they are exposed to high temperatures. The temperatures and even the finish of the pieces is not always favorable when mechanical interactions are performed between them [7]. In addition, there are small errors that may exist in the model and, when trying to correct them, compromise the functionality of the model.

Advantages associated with additive-manufacturing production, according to Zahera [14], are denoted in first instance by the complexity of form, because with this type of process products involving great difficulty, because of their characteristics and the way they are conceived, they are more manageable and there is no cost increase. Therefore, while complex geometry usually involves an increase in cost with conventional processes (subtractive or conformative), when additive manufacturing is applied, it can even involve a lower costs or simplification.

Another advantage refers to the adaptation of the shapes to human biomechanics, therefore the designs achieve a better interaction with the user without necessarily affecting manufacturing costs (ergonomics, customization), which provides clear applications for the medical health sector.

Dental specialties, in relation to 3D printing, focuses on topic related to oral surgery and prosthodontics, followed by orthodontics, however, it should be mentioned that there is a limited number of publications that deal with the applicability in periodontics and endodontics [1]. On the other hand, the use of 3D printing involves the production of drill guides for different dental implants, as well as the manufacture of physical models for prosthodontics, orthodontics and surgery. In addition to the manufacture of dental [11], craniomaxillofacial and orthopedic implants, and the manufacture of copings and structures for implants [23], in addition to the types of dental restorations.

The progressive application denoted in processes that are advanced in 3D printing methods in recent times, in addition to its use in regenerative medicine, tissue engineering and research, become fields of interest requiring more attention from scientific publications. For example, the development of bioprinting, which uses bioprinters, based on cellular ink, has been responsible for developing artificial tissues [24], and has been shown to allow the configuration of complex 3D models in vitro.

The development 3D printing types in the field of dentistry, shows the significant increase in the number of publications on this subject, which has increased mainly during the last 10 years, which makes this type of study of particular interest to dental professionals [24], since 3D printing is heading as the future of processes in dentistry in general.

Digital manufacturing technologies currently constitute an integrated system that allows the design, analysis and manufacture of functional parts, pieces and systems with different unprecedented advantages, radically changing the way of designing and prototyping, among other aspects [15]. This results into a revolution that is being observed in various fields, such as entrepreneurship, education, medicine, industrial design, engineering, architecture, science, art, among others.

Faced with subtractive digital manufacturing technologies, Torreblanca [15] is characterized by the roughing of material or cutting from a CAD file that was initially 2D (two dimensions) and later the 3D CAD files were integrated. Some examples of these technologies are milling machines (CNC router), CNC lathes, CNC machining centers, laser, water and plasma cutting, among others.

It is worth mentioning that companies are currently trying to improve their competitiveness, often based on logistics processes. Technologies such as additive manufacturing have been disruptive because they started with changes in manufacturing methods, through the generation of prototypes and products through a printer [25], evolving from subtractive methods that eliminate the material to the generation of objects by adding material.

Additive manufacturing as a new generation of product manufacturing processes has gained recognition since its appearance in the late 1980s where each part is manufactured layer by layer from a computer-aided design (CAD). In contrast to the traditional method where material is removed from a solid piece requiring planning of manufacturing processes. The spectrum of applications of this type of technology is included [26] by the automotive industry, aerospace, engineering, medicine, biological systems, food and supply chains.

In reference to the study by Christoph, Muñoz and Hernández [5], additive manufacturing in the health sector offers benefits in terms of surgery planning, by using precise anatomical models. The development of orthopedic implants and prostheses adapted to the specific needs and dimensions of the patient, use of human parts printed in 3D, and printing of living tissues to perform tests related to the development of new medicines, among other advantages.

In general medical implants, metallic materials are normally used during which numerous techniques were established to improve the integration of these implants in the human body, then, additive manufacturing methods, according to González and Quenard [16] have allowed the manufacture of parts of greater geometric complexity, providing the possibility of easily making modifications to the design. The variety of 3D printing technologies also makes it possible to obtain parts made of different materials.

In subtractive manufacturing, for the manufacture of dental pieces in implants, metallic material is used through machining techniques, therefore, pieces or implants are conceived from the elimination of material, either by chip removal or by abrasion, as described by the aforementioned authors.

For a comparison between the subtractive and additive process in teeth, in order to establish advantages and disadvantages in the supply chain. González and Quenard [26] have the following opinion on this subject:

The machining by chip removal consists of a tool with several blades that in several passes separates chips from the material, through roughing processes, where most of the material is removed with relative precision, and finishing processes, where a lesser amount of material with higher precision. On the other hand, in abrasion machining an abrasive wheel is used that is responsible for progressively wearing the material, detaching material particles.

Another technology in subtractive manufacturing for the shaping of metal implants consists of metal injection molding, which is based on the creation of solid metal parts from powders, which are composed of metal powder and a thermoplastic binder. This technology is used in the manufacture of medical instruments and implants with a variety of materials [16]. Most of the medical instruments are produced with stainless steel, generating pieces such as scalpels and forceps. Finally, it can be noted that additive manufacturing studies have increased in recent years, which have positioned themselves in the scientific community [27], as stated by Núñez in his article Additive manufacturing and supply chain: Bibliometric review and analysis.

B. Additive Manufacturing Steps in Dental Pieces

1) Input of materials

In this procedure, the aspects inherent to the conformation of characteristics that adhere to the design and the forms conceived for the structuring of the dental piece are detailed, therefore, what is detailed below meets a number of steps and phases that give an overview of the procedures performed in additive manufacturing in dental pieces.

Design input: different design features and different shapes: tooth creation, tooth scan, mold creation, and more. Characteristics of 3D printing: STL file (triangle file and it is the way the computer reads to be able to print)

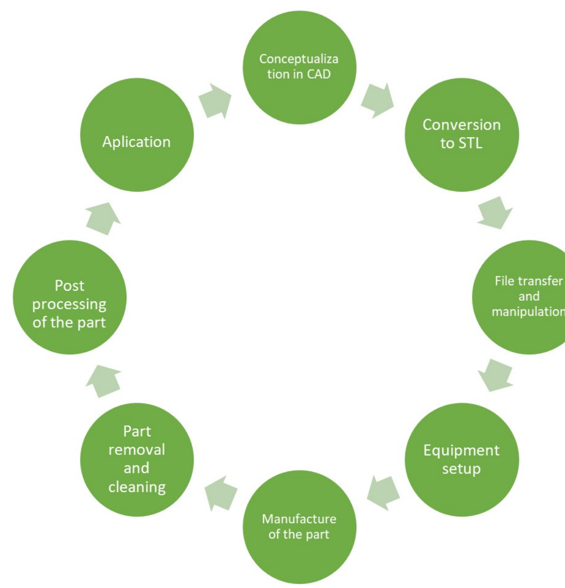

Figure 1. General additive manufacturing process
Source: National Chamber of the transformation industry (CANACINTRA)

1. Conceptualization in CAD. The first step in any additive manufacturing development process is to have a clear idea of the object, in terms of its presentation and operation. The general additive manufacturing process begins with the source data for the object design in 3D CAD programs, which can be generated through an automated optimization algorithm, existing physical parts, or some combination of both.

2. Conversion to STL. The vast majority of MA technologies use the STL file format, derived from the Stereolithography technique (it refers to a manufacturing process by addition that uses resin transformed by an ultraviolet laser for the construction of objects build three-dimensional objects, which are obtained by adding thin layers, printed one on top of another).

The STL format integrates the modeling history, the construction data of the object and the approximation of its surfaces with a series of triangular facets.

3. Transfer and manipulation of STL files. Once the STL file has been created, it can be sent directly to the additive manufacturing team. Ideally, it should be possible to press a "print" button and the machine should begin to build the object.

4. Equipment Configuration. Additive manufacturing equipment has specific configuration parameters for its machining or process.

5. Manufacture of the Piece. The scheduling of manufacturing activities, the first stages of the process are semi-automated tasks that may require considerable manual control in interaction and decision-making. Once these steps have been completed, the process is switched to the computer controlled manufacturing phase. All additive manufacturing equipment will have a similar sequence of layers, including an adjustable height platform, material deposition, spreading mechanisms, and layer cross-sectional formation.

6. Pieces Extraction and Cleaning Ideally. The final product resulting from additive manufacturing equipment should be ready for use with a minimum of manual intervention.

7. Post-processing of the Piece. Post-processing refers to the finishing stages of the pieces, generally carried out manually. This phase may involve an abrasive finish, such as polishing and / or sanding, or the application of coatings, according to the specifications of the product and / or process.

8. Application After the final post-processing, the manufactured piece would be ready for use.

2) In dentistry, the process is performed from a CAD / CAM design and occurs in three (3) parts:

1. Taking records: this is, obtaining digital models, photographs, tomography, among others [28]. An element is required to capture the information; it can be by tomography, however, most of the time a 3D model of the mouth is needed, which can be done by using a model scanner or with an intraoral scanner.

2. The design: where you work on the computer to create the piece that is required, how it will be, for which the diagnosis is considered.

3. The manufacture: the manufacture of the part with 3D printing.

IV. Methodology

This study was approached from a systematic review, which was carried out with adaptation of the Prisma methodology and the use of some aspects that adhere to the Tranfield methodology [29]; the used steps of the methodologies are:

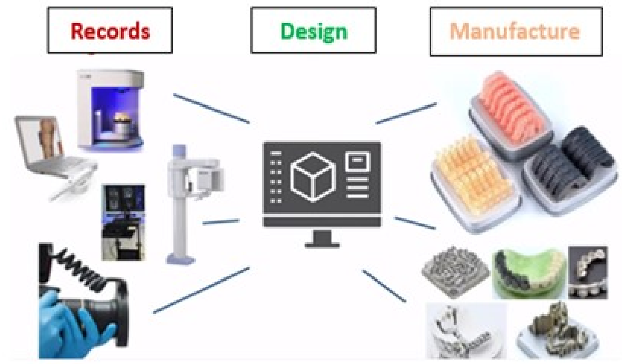

Figure 2. Additive Manufacturing
Source: National Chamber of the transformation industry (CANACINTRA)

Prism methodology.

1. Title.
2. Summary.
3. Introduction.
4. Objectives.
5. Methods.
6. Eligibility criteria.
7. Information sources.
8. Search.
9. Selection of studies.
10. Data extraction process.
11. Data list.
12. Summary measures.
13. Synthesis of the results.
14. Additional analysis.
15. Results.
16. Study characteristics.
17. Results of individual studies.
18. Synthesis of the results.
19. Additional analysis results.
20. Conclusion.

It should be noted that the Prisma statement is a kind of derivation of the Quorom Statement. This establishes the need for reviewing and updating the guidelines in accordance with maintaining, eliminating or adding new items to the checklist initially established by Quorom. Therefore, an extensive document detailing the explanation or justification for each of the 27 items proposed in this statement must be included, as well as the processes performed in its remaking of these guidelines [29], which incorporates various conceptual and novel methodologies related to systematic review methodologies. For the purposes of this it should be noted that some of the items proposed in this methodology were used, which are in accordance with the search criteria and the relevant filters in order to obtain the appropriate scientific articles on the research subject.

Tranfield methodology.

1. Formulation of the research questions.
2. Literature location.
3. Selection and evaluation of localized articles.
4. Content analysis and synthesis.
5. Presentation of the research results and gaps.

The RLS methodology is a benchmark in areas related to knowledge transfer, which has been developed in medical sciences as a way to synthesize [30] research, therefore the findings are presented in the form of methodical and documented steps, in order to ensure the transparency and reproducibility of the information.

The research was developed based on scientific articles in the field of oral health, typical of dentistry, which were disseminated by indexed journals, which come from recognized databases of academic prestige.

From the developed processes, about 900 articles were reviewed, obtained from Scopus and Web of Science databases, most of which were published by different journals. The period initially taken was 1990–2021, in addition to certain inclusion criteria for conducting a search in accordance with the literature on the mentioned subject, where the construction of a strategy was conducted based on the characteristics of each database.

Appropriate keywords were used, this allowed a greater inclusion of possible articles and the application of filters allowed according to the database, in order to expand the results or delimit them, thus achieving greater precision in the collection of information. The keywords for the information search are subtractive and additive manufacturing in dental pieces.

A. Instruments and procedures

A registration form was designed. Data extracted from the sample of the Scopus, Web of Science databases were established, according to selection elements such as author, title, year and other bibliographic data of the documents. Each of the selected article will be registered as an entry in each row of the file to later be filtered and analyzed according to the criteria specified in the columns of the file. Articles related to the subject of additive and subtractive manufacturing in dental pieces will be selected, based on the adaptation of the Prisma methodology, which has 27 criteria as a checklist of the different items to include in the systematic review.

B. Justification of Selected Databases

Web of Science and Scopus databases were chosen because they are widely used and relevant in Latin America and in the world. They allow consulting publications of scientific-academic publisher [31], in the case of Scopus [32], for the Spanish Foundation for Science and Technology; it is considered as the most important in the world and belongs to the Elsevier platform.

The Web of Science platform owned by the Clarivate Analytics company, is the collection of databases of bibliographic references and citations of periodical publications that collects information from 1900 to present time. Hence its importance, it is composed of the basic Core Collection that includes the indices of Sciences, Social Sciences and Arts-and-Humanities, in addition to the Proceedings of both Sciences and Social Sciences, and Humanities together with the tools for analysis and evaluation, such as the Journal Citation Report and Essential Science Indicators. Additionally, it has the databases that complement it included in the license for Spain [32]: Medline, Scielo and Korean Citation Index.

An analysis tool presenting statistical data on citations from 1997 onwards, providing a vision of the importance of journals within their subject categories (journal impact factor) is presented in Science edition and Social Sciences edition. It offers a systematic and objective means of evaluating the world's leading research journals [32] by providing the number of citations and articles from virtually all science, technology, and social science specialties.

It searches more than 12000 journals and more than 120000 science, social science, arts, and humanities conference proceedings to find the highest quality and most relevant research for your fields of interest [33]. Create links between relevant research using cited references and explore thematic connections between articles created by expert researchers.

The Scopus database is a leader in Bibliographic Indexing, it is the largest database of peer-reviewed abstracts and literature and has intelligent tools that allows controlling, analyzing and visualizing academic research. More than 3,500 academic and govern organizations, corporations including more than 150 funding and evaluation bodies, use Scopus [34], it includes content from more than 5000 publishers and 105 different countries.

Scopus is a database of bibliographic references and citations from the company Elsevier [35], of peer review literature and quality web content, with tools for monitoring, analysis and visualization of research.

According to the Spanish Foundation for Science and Technology, the Scopus database allows:

Perform different search options.

Document search, by author, by affiliation and advanced search for expert users in the construction of complex searches.

Functionality "Citation Overview" [32], which allows the calculation of citations for selected articles, all articles by a specific author or all articles published by a specific journal in a year.

Affiliate or author profile. They allow an analysis of the research performance of an institution or an author.

Journal Analyzer. It is a tool to evaluate the performance of a scientific journal. About each magazine provides three graphs that report on:

Total number of citations received each year (Total Citation Graph).

Number of articles published in a period of time (Articles Published Graph).

Total number of citations divided by the total number of published articles (Trend Line Graph).

Allows comparing up to 10 magazine titles simultaneously.

Impact metrics:

SJR (SCimago Journal Rank): A metric that weights according to the prestige of a magazine. It equally distributes the prestige of a journal among the total number of citations of the same and normalizes the differences in the behavior of the citation of the different thematic fields.

SNIP (Source Normalized Impact per Paper): measures the impact of an appointment according to the characteristics of the investigated subject. On the one hand, it evens out the differences in citation between the different subject fields, and on the other, it evens out the differences in their coverage by providing a normalized metric that allows the comparison of journals of different categories.

CiteScore: Calculates the average number of citations received among all documents published in the three years prior to the metric. Updated annually and presented in addition to the indicator; the percentiles of the indicator are presented.

H Index: Impact indicator of the production of a specific author. This indicator shows a balance between the number of citations a researcher receives and the number of publications he has made throughout his career.

C. Inclusion Criteria

After having more than 900 articles identified, they are selected through the data search, they are reviewed by title and the duplicates are eliminated; Subsequently, the articles evaluated for eligibility are reviewed, they are classified and chosen if they are considered relevant or not according to the subject of work. Other articles are excluded, then the basic components of the search strategy and the criteria of the authors.

In summary, it can be said that a detailed assessment of the total articles is performed through a data extraction form developed for this review. Considering the following inclusion criteria or subcategories: (a) Articles must be published in English or Spanish, (b) they must be peer-reviewed articles, (c) they must be articles that are approached from an additive and subtractive manufacturing approach; finally (d) the subject should be addressed by focusing on additive and subtractive manufacturing in dental pieces, that is, from the dental clinic. From the application of this extraction form, the total of viable articles must remain for the subsequent analysis that meets the project objectives (See Figure 1).

D. Data Extraction

A worksheet will be developed for the full articles included in the review, extracting the following elements:

(i) Study characteristics: author, title, year of publication, journal.

(ii) Methodology and analytical process: empirical study, qualitative study, quantitative study, interview, longitudinal study, literature review, single case study, focus group or cross-sectional study.

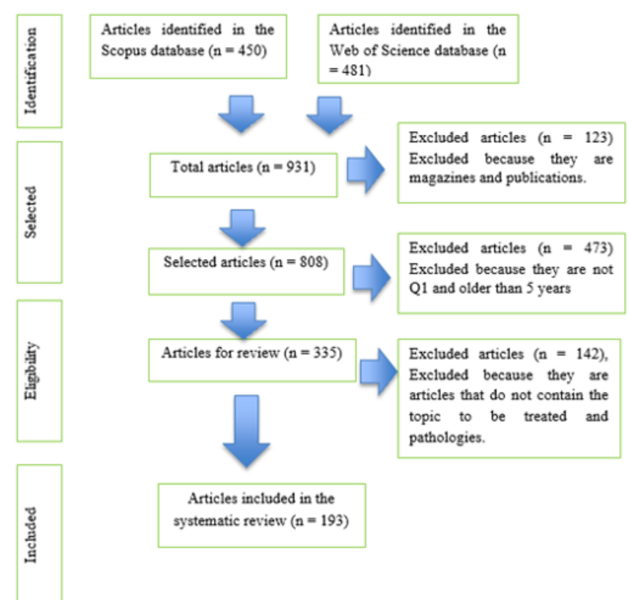

Figure 3. Methodology flow diagram
Source: Author

E. Search procedure

From the resolution of Boolean operators, the search platforms, the equations defined below were defined:

Results: 400 Web of Science.

Equation: (additive-manufacturing OR 3d-print *) AND (dentistry OR denture OR endodontics OR dental-implant OR dental-pieces).

Type of documents: articles.

Time period: every year.

Indexes: SCI-EXPANDED, SSCI, A & HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.

Results: 408 Scopus.

Equation: ((additive AND manufacturing OR 3d-print *) AND (dental AND implant) OR (dental AND pieces))) AND (LIMIT-TO (DOCTYPE, "ar"))

The search process for the articles resulted in the aforementioned equations that were adjusted to the Web of Science and Scopus databases. The conducted process is detailed step-by-step below:

First, the search was done for articles referring to the subject of this research, for example, with keywords such as 3D printing for teeth, additive and subtractive manufacturing of teeth. Subsequently, the articles were reviewed in relation to the keywords, then a list of all the keywords was made, then the articles related to the forms of impression and dental impression technologies, concerning mainly the procedures they perform in dentistry, generally focused on dental or dental processes conducted with patients and dental forms.

In summary, different articles related to additive and subtractive manufacturing in dental pieces were reviewed (first step), then, the list was prepared with all the words that were considered key (second step), later the words that were believed to be most important in relation to the subject were reviewed. Thesaurus platform was consulted searching for synonyms of those keywords to further strengthen the search process (third step). After having the information, which was done in order to review the Boolean operators best suited to the search process to achieve better results (fourth step), it was determined the cases these Boolean operators were used, in order to establish their use, either for words as a whole, words unique, among other aspects. Finally, the equation (fifth step) was constructed both for the part of the impression forms, as well as for the dental processes or dental processes in the patients.

Regarding Boolean operators, in this case what they do is connecting or restricting the search terms. It should be noted, as evidenced in the equations, that OR-AND operators were used in the Web of Science and Scopus database, since It was intended to search for records that included all the terms separated by the operator, in order to combine terms to broaden and refine the search. In this case, included terms were additive manufacturing, 3D printing, dentistry, teeth, endodontics, dental implant and teeth; therefore, what operators do is locating records in the database including any of the terms above described.

F. Search methodology

Having the two search equations created, it was possible to have as a result 931 articles, from the Scopus and Web of science databases, talking about the research subject, where, from the used filters, the information was refined to finally have those considered relevant.

The conducted process was performed in Excel files, this in order to be able to adjust the debugging with the corresponding specified filters, which is listed below:

Step 1: in this step, two phases were performed, as follows:

Phase 1: from the exploration conducted in the selected Scopus and Web of science databases, 931 articles were obtained, 450 from Scopus and 481 from the Web of Science, having 123 corresponding to journals and other publications that were eliminated, thus leaving a total of 808 being scientific articles.

Phase 2: For the remaining 808, and using the Vantage point program, a classification was made by year and by quartile, more specifically the information of the articles was specified by title, subtitle, citation time and year of publication. In the following procedure, the quartile and the SJR (impact factor) were identified through the Scimago journal program, a task performed manually, where the articles were classified for the last 5 years (2021-2020- 2019-2018-2017-2016). Thus, 473 articles were eliminated from this procedure, leaving 335 that had in common that they were classified in quartile 1 and were published during the last 5 years.

Step 2: the 335 articles selected were put in a new file, and it was established that the abstracts of each of these articles would be reviewed, in such a way that it could be determined from selection criteria by categorizing the articles:

- Rejected (why?) Is this justified.

To talk about some pathology,

The article did not have a summary

The article it was repeated

It is rejected because it does not talk about the specific topic (teeth)

- Materials.
- Print / Print Type.
- Advantages / Benefits.
- Entry.

After this procedure, 142 were eliminated, thus leaving 193 articles.

Step 3: of the 193 articles that were chosen from the previous step, we proceeded to review the characterizations that each of the articles spoke about in their abstracts, such characteristics were defined according to selection criteria such as materials, printer / type of impression, advantages / benefits and entry. None of the articles were eliminated in this step, because all of them had at least one of the four characteristics previously mentioned.

Step 4: Reviewing the 193 articles for the material criteria and printer / type of impression, referred to these specific aspects, articles speaking of specific materials on dental pieces. It should be noted that this procedure was performed with the aid of a dental professional, having deeper knowledge on this subject. This resulted in a classification of them as follows:

Ceramics molded with natural plastic raw materials and permanently hardened by heat. Metals having good mechanical properties, characterized by their high degree of resistance to contraction, pressure, and traction, they also have properties of malleability and ductility, which defines that they are capable of forming sheets and threads respectively. Resins [36] that are aesthetic restorations of the teeth, which can be used in damaged or decayed teeth, material used is precisely Resin. This is worked considering teeth color, therefore the result is a cosmetic and pleasant restoration. Polymers [37] that are compounds consisting of large organic molecules formed by the union of many repeating units. They can be used for the construction of prostheses, splints, orthodontic appliances, impression holders, complete prostheses and for constructing base plates, plaster [38] one of the materials most used in dentistry, a mineral having white pigmentation. Acid [39] used in dental interventions as an adhesion system between dentin or dental enamel, and as filling material in dental restorations (crowns, bridges, veneers, root pins, etc.). Cements [40], a biomaterial of multiple composition and fluid consistency applied between two surfaces with double the objective of joining them, maintaining the restorative treatment performed by the dentist, and protecting them, acting as a barrier that prevents the filtration of bacteria and debris.

Articles related to printers, type of printing and additive manufacturing in dental pieces were reviewed, described as follows:

Extrusion of material (FDM) [41], an additive manufacturing system where a computer-controlled extrusion head extrudes a wire of plastic material. Polymerization (SLA, DLP) [42] 3D printing process, where a photopolymer resin in a tank is selectively cured by a light source. Most common forms of VAT polymerization are SLA (stereolithography) and DLP (digital light processing). Powder bed fusion (Polymers) [43] Selective laser sintering (SLS) fusion 3D printing technique powder, generally nylon (polyamide) consisting of heating a polymeric powder to a temperature just below the melting point of the polymer, in a container. Powder bed fusion [44] technology of 3D printing that uses a powder material, depositing layer by layer, applying to each layer a source of thermal energy melting it with the programmed shape, until the desired object is formed. Thus existing five processes that use powder bed fusion technology: EBM, SLS, SHS, SLM and DMLS.

Consequently, 70 articles were eliminated and 123 articles remained.

Step 5: In this step, the types of materials that refer specifically to dental pieces were classified. The types of additive manufacturing impressions on dental pieces were also classified. Materials were ceramics, metals, resins, polymers, plaster, acid and cement. Printing types were FDM material extraction, SLA curing; DLP; powder bed fusion (polymers) (SLS); Lamination of LMO parts; powder bed fusion (materials) (DMLS, SLM, EBM).

Step 6: The 123 articles were reviewed by title, materials, type of printing and post process. From this review, remained 20 articles related to material and type of printing (the article must meet the criterion, spoking of both material and type of printing). Another filter was made based on the following criteria: material, type of printing and post process. Therefor 12 articles were eliminated after this procedure, thus 7 articles that meet these characteristics remained.

Step 7: in this step, it should be noted that six articles were downloaded from the Scopus and Web of Science platforms, that is, for discussion and results, the mentioned articles will be reviewed, since it was not possible obtain one for its analysis, therefore, 6 articles were analyzed.

V. Results

After the conducted process, it was determined that, based on the inclusion criteria defined for the results of the study, only 6 articles, from 931, meet the requested requirements. In final instances there were 121 articles obtained through filtering: defined by title, materials, type of printing and post process. Therefore, it was decided to include one more filter for the fulfillment of the criterion that spoke of material and type of printing, in this way the relevant articles for the present investigation were ultimately obtained.

The following is a graphical representation of the procedure performed in order to obtain the articles defined as pertinent regarding the additive manufacturing processes in dental pieces.

Having 808 articles obtained from the selected Scopus and Web of Science databases, the following graphs were constructed:

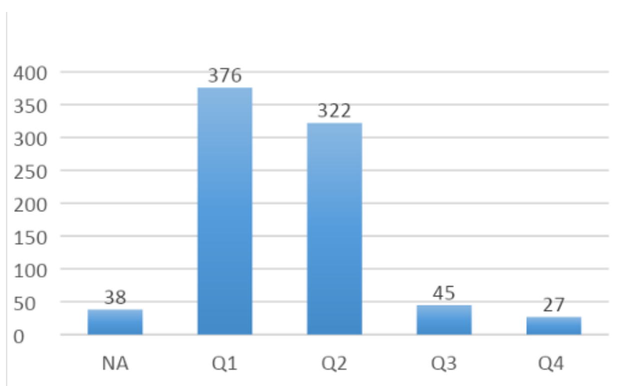

Figure 4. Quartiles
Source: Author

Figure 4 shows the average number of citations by quartile, each item corresponds to an indicator that serves to evaluate the relative importance of an article within the total number of articles on this field. In this specific case regarding those obtained from the initially defined databases. The data in the graph was obtained from the 808 articles previously identified in the methodological procedure performed, where the following classification could be established:

.

Q1: Is the most significant with 376 articles.

Q2: less relevant, compared to Q1 with 322 articles.

Q3: Below the above with 45 items.

Q4: Is the least significant with 27 articles.

From the above, it can be determined that Q1 are the most significant publications, which corresponds to the 25% of articles that are considered most important in the scientific literature, logically referring to this particular case.

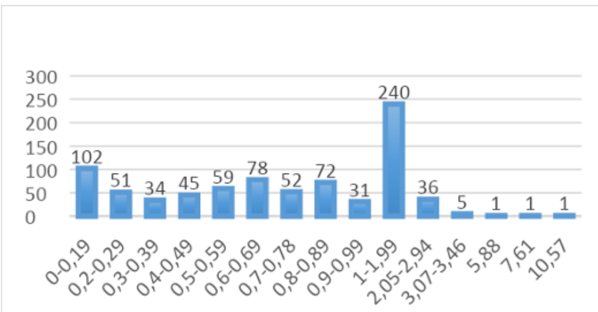

Figure 5. Year of publication
Source: Author

Figure 5 shows the impact factor, which measures the impact that a journal has on the scientific community, therefore, in this case the largest number of articles is concentrated in the range between 1–1.99, this being the most representative. The next rank with the highest number of articles is 0-0.19 and, in the third place is the rank 0.6–0.69. This means that 240 articles obtained a much higher impact compared to the rest of the publications obtained from the databases.

With the 193 selected articles, the following graphs were constructed:

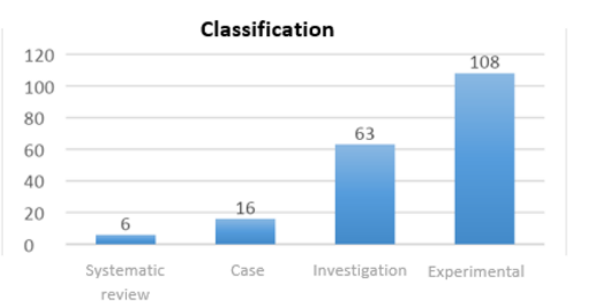

Figure 6. Articles classification
Source: Author

Figure 6 shows the classification for each of the articles, according to the exposed topic. It can be seen that the highest number of review articles is found in the Experimental topic with 108 articles, followed by research with 63 articles, then Case category having 16 articles and finally a Systematic review with 6 articles. This classification allows classifying each article according to its objective, which allows the researcher to know which topics are the most appropriate for the study.

Table 1 shows the numbers of the titles of the articles initially coded by numbers, for greater practicality. It could be noted that they were detailed by material, that is, the types of raw material that refer to each article in particular. This with the purpose of filtering the articles that not only refer to the subject (additive manufacturing), but also the types of materials that are used in the procedures they describe, all this with the aim of locating the subject with greater precision.

As can be seen, Table 2 shows the type of impression. Articles related to this specific topic are classified; there it can be found the number of articles considered for the systematic review. Below are presented the details from Table 1 materials and Table 2 type of impression:

Materials, 128 articles.

Articles with common materials 36.

Total materials: 92 articles.

Printing type: 58 items.

Items with common printing type 7.

Total type of printing 51 articles.

Total articles: 123 articles.

As can be seen, from the process of materials and type of printing, 123 articles were selected for review.

The 123 articles were reviewed by title, materials, type of printing and post process. From this review, 20 articles were selected because they deal with material and type of printing (the article must meet the criterion for both material and type of printing). Another filter was made based on the following criteria: material, type of printing and post process; 12 articles were eliminated from this procedure, therefore 7 articles meeting these requirements remained. Six articles were downloaded from the Scopus and Web of Science platforms. For one of them, pertinent information for analysis could not be obtained, therefore, 6 articles were analyzed.

Next, the publication trend is presented. From the figure, the trend behavior of the performed process is shown.

Table 1. Materials
Source: Author

Materials	Title	Total
Ceramics	5, 286, 30, 183, 212, 316, 326, 48, 199, 215, 225, 229, 232, 240, 271, 290, 307, 72, 78, 166, 174, 197, 198, 217, 224, 273, 283, 293, 249, 324, 332, 313, 288, 289, 322.	38
Metals	7, 9, 166, 202, 17, 23, 136, 148, 200, 219, 234, 244, 246, 250, 319, 333, 78, 174, 197, 198, 205, 207, 217, 229, 81, 216, 218, 265, 266, 284, 309, 82, 91, 176, 177, 184, 264, 277.	37
Resins	15, 2, 58, 59, 331, 84, 110, 126, 131, 169, 178, 179, 185, 200, 214, 223, 247, 249, 258, 263, 279, 282, 287, 288, 296, 310, 329, 168, 192, 220, 332, 201, 316, 317, 334, 102, 137.	37
Polymers	97, 112, 263, 287, 138, 139, 153, 173, 200, 90, 261, 262, 270, 282	14
Plaster	160, 313	2
Acid	263	1
Cements	326	1

Table 2. Print Type
Source: Author

Print type	Title	Total
Material extrusion (FDM)	39, 176, 228	3
Polymerization (SLA, DLP)	13, 20, 48, 129, 254, 261, 289, 331, 15, 57, 59, 62, 72, 91, 160, 167, 290, 21, 71, 279, 282, 182, 153, 262, 328.	25
Powder Bed Fusion (Polymers) (SLS)	6, 9, 91, 244, 7, 37, 66, 73, 77, 86, 91, 94, 98, 123, 158, 165, 166, 177, 198, 202, 233, 234, 284, 333.	24
Powder Bed Fusion (Materials) (DMLS, SLM, EBM)	7, 9, 136, 205, 207, 200	6

Figure 7. Year of publication
Source: Vantage Point

Figure 7 shows the number of articles that were used for the systematic review, according to the year of publication. The data listed in the figure were obtained from the 193 articles previously identified in the methodology, step number 4. The largest number of published articles were found in 2020, followed by 2019 and 2018.

The review was performed from 2016 to 2021. The X axis shows the year, the Y axis shows the number of publications. It is evident that there is an increasing trend line and, in the last year, it decreases. It can be seen that in 2020 around 70 articles associated with the topic were published, reporting the highest number of articles dealing with the addressed topic.

Figure 8. Authors
Source: Vantage Point

Figure 8 presents 193 articles, selected from authors. The number of articles published by each of the authors can be observed, being the most relevant Revilla León, M., who has published about 14 articles on this subject. For greater detail, it must be said that he is a politician, writer, graduate in economic and business sciences, currently working in banking on leave of absence, standing out as a writer of scientific articles in the branch of the 3D fabrication in dental pieces related to cases in patients. For this review, as above mentioned, 14 scientific articles of his authorship are evidenced. Another author is Özca, M., his scientific articles are focused on the area of dental clinical cases associated with different additive manufacturing technologies, and 12 scientific articles were found in the review. Finally, for those having the largest number of articles, is Kim, J.-H. His scientific articles are related to the experimental field (preparation of dental pieces), where he seeks evaluating his behavior, thus obtaining seven (7) scientific articles for this systematic review.

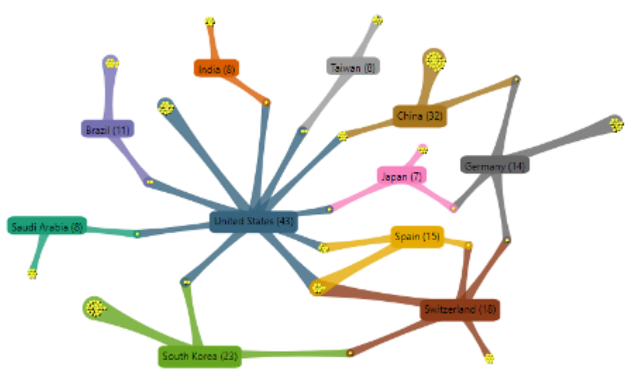

Figure 9. Country Relations Map
Source: Vantage Point

Figure 9 is based on the classification of the countries contributing with seven or more publications. The largest number of contributions come from the United States, Spain and Switzerland, 8 articles, followed by the United States and China with seven –7– articles, lastly Spain and the United States with 6 articles, these being the most important resulting from the systematic review.

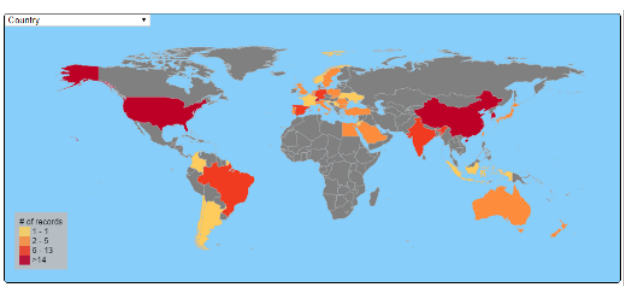

Figure 10. Place of origin of the articles
Source: Vantage Point

Figure 10 shows the countries with the greatest participation in the conducted systematic review, specified by color. The following figure shows specific details.

Both, Figures 10 and 11, show the countries considered being the most relevant in the systematic review.

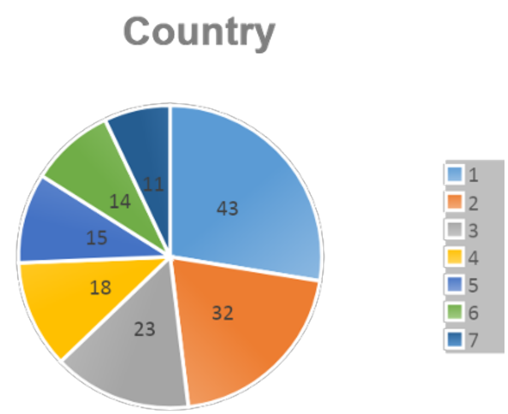

Figure 11. Article countries
Source: Vantage Point

It can be established that they were selected based on these having more than 10 publications. The most relevant are the United States with 43 publications, followed by China with 32 publications and South Korea with 23 publications, thus evidencing the impact of the processes performed with 3D printing for elaborating dental pieces. It can be noted that these countries constitute the top seven, having an equivalence of 57% of participation compared to the rest of the publications of this review.

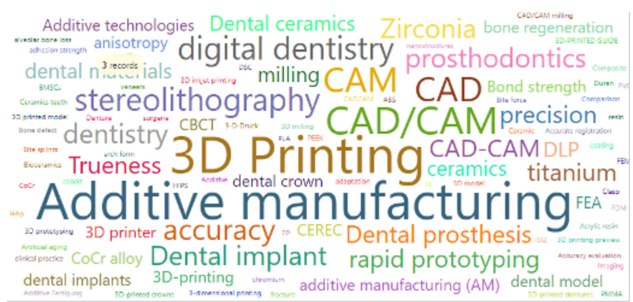

Figure 12. Keywords
Source: Author

Figure 12 shows the most representative keywords in the systematic review. Keywords were defined based on the field and object of study for this research. Among these words, we have; Additive manufacturing having the record of 54 words, 3D Printing with 50 words, CAD / CAM with 18 words, and Stereolithography with 11 words.

Figure 13 shows matrix of knowledge networks, for the top of related authors, the first being Revilla León, M. and the second one being Ozca.

Figure 14 shows the top of the most cited articles. Being the most cited College of Dentistry, with 13 scientific articles, Revilla Research has 12 scientific articles and School of Dentistry has eight scientific articles.

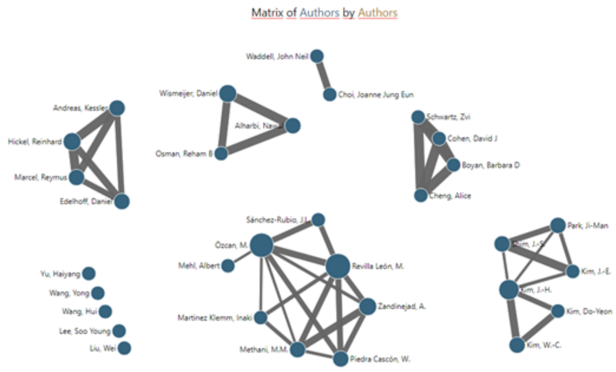

Figure 13. Matrix of knowledge
Source: Vantage Point

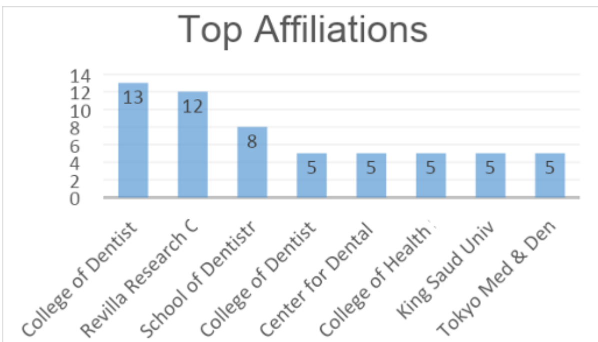

Figure 14. Top Affiliation
Source: Vantage Point

Figure 15 shows the Top of the most published journals, and the number of articles for each of these journals. Being the Journal of Prosthetics with 39 articles the first, Journal of Prosthodontics with 13 articles, the second, and the third Dental Materials with 9 articles.

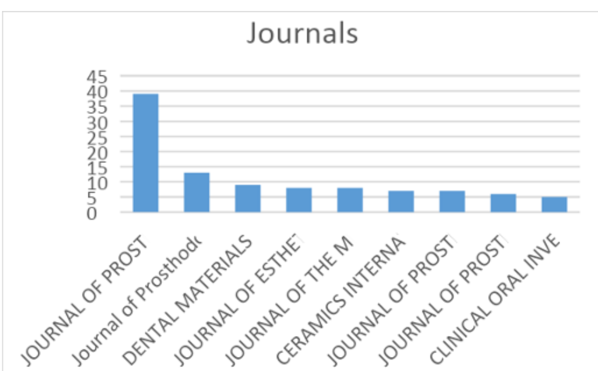

Figure 15. Magazines
Source: Vantage Point

Table 3 presents the comparison between subtractive and additive manufacturing in dental pieces according to the established characterizations.

In order to conclude, as a synthesis of the conducted process, based on the methodological aspect, all this to find the articles considered suitable for the analysis, all of them that passed the different filters and meet exclusion criteria established. It can be said that different aspects, such as quartiles, were reviewed during the process, which was done initially to establish the most relevant publications according to scientific journals and their content.

Subsequently, the impact factor (SJR) was observed, and a classification of the articles was made according to the exposed subject and by means of the material criteria and type of printing, 140 articles could be selected.

A trend of publications per year was also traced in order to establish the largest number in a specific year. The largest number of publications were obtained for 2020 with 70 articles; similarly, the process was performed for publications by author. The countries contributing most of the publications and keywords were also reviewed, among other aspects defined for those definitely selected, resulting into six –6– articles for their respective analysis.

As above mentioned, six articles could be analyzed. These articles were considered, according to the systematic review, to be the most conducive to address this subject. The corresponding analysis is presented below.

The first article analyzed was "Reproducibility of different arrangement of resin copings by dental microstereolithography: Evaluating the marginal discrepancy of resin copings" [45] and refers to the problem statement Microstereolithography (μ-SLA), which is a form of additive manufacturing, It can produce one or more resin copings platforms. However, no assessment of marginal variance with discrepancy has been performed using this method, although this is an important factor for a successful restoration. The purpose of this study was evaluating the reproducibility and marginal discrepancy of resin copings manufactured using dental μ-SLA. In the conducted process, statistically significant differences were found between the groups compared.

The authors' conclusion is defined from the marginal discrepancy, μ-SLA of additive manufacturing is more accurate when using 3 matrices than when using 1 or 6 matrices on a single build platform. Because of the adjustment that It is affected by the number of copings manufactured, it is pertinent to conduct additional research in contrast to multiple cofiasse resins that are required.

Other research focuses on the effect of porcelain firing and cementation on marginal fit, "Effect of porcelain firing and cementation on the marginal fit of implant-supported metal-ceramic restorations fabricated by additive or subtractive manufacturing methods" [46], which is performed in implant-supported metal-ceramic restorations fabricated by additive or subtractive fabrication methods. The objective was focused on comparing the marginal and internal values. fit of 3, 4 and 5-unit Co-Cr metal structures cemented and supported by implants manufactured using lost wax techniques (LW), CAD-CAM milling and selective laser fusion (SLM), where assisted design systems Subtractive and Additive Computer and Computer Aided Fabrication (CAD-CAM) have been used in the fabrication of large-scale cobalt-chromium (Co-Cr) restorations. However, the defit accuracy of multi-unit frames is unclear.

The study in its process involved the manufacture of 90 Co-Cr metallic structures for cemented restorations supported by implants of three, four or five units on original abutments with three subgroups of different manufacturing techniques (LW, CAD-CAM milling and SLM). The effect of the manufacturing techniques and the number of units (groups) on the discrepancy values was evaluated using a full factorial ANOVA model.

Table 3. Comparison Chart

Comparative Chart					
Characterization	**Subtractive**	**Additive**	**Characterization**	**Subtractive**	**Additive**
Materials	Ceramics, Metals, Resins, Polymers, plaster, Acid.	Ceramics, Metals, Resins, Plaster.	Human Resource (How people participate on it?)	To manufacture a single dental piece requires the participation of three or four people.	The own elaboration of the products, and the reduction of machinery can lead to fewer jobs in manufacturing.
Printer/Print Type	Traditional elaboration	Material extrusion (FDM), Polymerization (SLA, DLP), Powder bed fusion (Polymers) (SLS), Powder bed fusion (materials) (DMLS, SLM, EBM).	Time Times used in the production of teeth are longer.	The decrease in work times, compared to conventional techniques that are mostly manual	
Process	Impression taking, part manufacturing, Application.	Conceptualization in CAD, Manufacture of the Part, Application.	Cost Increased costs when the geometry of the pieces is complex. Unit cost of parts depends on high volume part production.	All costs are proportional to the hours that the machine is printing the dental piece, but it is more economical than the traditional piece.	
Post Process	Necessary adjustments according to the comfort of the patient.	Done manually, abrasive finishing, polishing and / or sanding, application of coatings, all of this in accordance with the specifications of the product and / or process.	Energy consumption There is higher energy consumption to run the machines.	It is one of the most economical when printing any tooth in 3D.	
Investment	The initial investment is low; in general, they are small and easily acquired machines.	The capital to invest is high, but its productivity is higher	Machinery expense	Imbalance over time from heavy work, requiring adjustment at least twice a year	They occupy little space and do not perform heavy work, their calibration is made by software most of the time.
Type of tools	Machines that are more robust are required to process the parts.	The tools needed for these machines are smaller and easily acquired.	Quality	Depending on the time of use and the calibration of the machine, as well as the experience of the operator, highly accurate parts are achieved.	The quality is excellent because it is computerized and different designs can be made.

The results emphasize that the mean marginal discrepancy of the 3-unit frames did not show statistical significance and large differences in the LW (35 metrom) and SLM (25 metrom) techniques; however, the frameworks fabricated by CAD-CAM milling (68metrom) had the highest marginal discrepancy values (p <0.001). The mean values of marginal discrepancy were 40 metrom (LW), 33 metrom (CAD-CAM milling) and 25 metrom (SLM) for 4-unit structures, and no significant differences were found between the fabrication techniques. The conclusion is that the CAD-CAM milling had the poorest margin fit values for structures of five –5– units, while the LW technique demonstrated the best results. The number of units had no meaning, which could influence the internal fit margin of the structures manufactured by LW.

Regarding the study "Influence of ceramic firing on marginal gap accuracy and metal-ceramic bond strength of 3D-printed Co-Cr frameworks" [47], they identify the problem from the marginal space and the resistance of the ceramic bond of the metal-ceramic restorations, the authors state that they are important for success. The purpose was to investigate the marginal gap of cobalt-chromium (Co-Cr) alloy structures produced by SLM technology before and after ceramic firing. In addition, the strength of the metal-ceramic bond was evaluated with the Schwickerath crack initiation test according to the International Organization for Standardization (ISO) 9693-1: 2012. The results determined that only 28 of the 80 dental technicians returned samples within a preset time and / or under suitable conditions. The mean marginal gap ± standard deviation of the structure before firing the ceramic was 25 ± 9 μm and 34 ± 12 μm after firing. The conclusion established that ceramic firing affected the marginal space; however, all Co-Cr structures had a marginal gap of less than 120 μm, which is reported to be a clinically acceptable cutoff. Most of the samples (80%) had a metal-ceramic bond strength value higher than the ISO 9693 requirement of 25 MPa.

Five of the 28 dental lab technicians were unable to comply with the ceramic firing instructions.

The article "Influence of novel implant selective laser melting framework design on mechanical durability of acrylic veneer" [48] refers to the design of a fusion structure by selective laser in mechanical durability of acrylic veneer, proposing a new design that improves the aforementioned procedure. The mechanical durability of the acrylic veneer in implant structures, manufactured from selective laser fusion (SLM), was compared with a novel design with conventional milled structures numerically controlled by computer (CNC), for this purpose, the titanium implant structures with distal cantilever were used, which were manufactured by SLM ($n = 10$) and CNC milling ($n = 10$). The CNC structures had multiple vertical pins, while the SLM structures had 3D metal networks of horizontal beams connected by vertical struts. All structures were coated with acrylic teeth, resin material, and subjected to a static load-to-failure test in the cantilever region. Load-to-failure readings and prosthesis damage pattern were recorded for each prosthesis.

Results showed that the CNC and SLM prostheses failed with statistically similar loads, hence the acrylic veneer around the CNC structures tends to initially crack around the distal implant followed by acrylic chipping, for greater specificity, it should be noted that six SLM prostheses failed in the connector of the mesial implant structure due to separation of the screw seat.

Ultimately, it is concluded that the SLM structure with a novel design is effective to reinforce the acrylic coating, however, the SLM structures seems to be weak in thin sections, such as the screw seat.

The objective of the article related to polymers for conventional manufacturing, and called "Polymers for conventional, subtractive, and additive manufacturing of occlusal devices differ in hardness and flexural properties but not in wear resistance" [49], is to investigate wear resistance of these types of components for injection molding in additive and subtractive device manufacturing. Compared to enamel antagonist dressing and material properties (i.e., hardness, flexural strength, and flexural modulus). The method used in injection molding was compared with milling and additive in technologies of stereolithography, low force stereolithography and with a type of digital light processing. For each material, eight specimens were produced for dressing measurements. The extracted human premolars served as penetrators. Results, indicates that the dressing modality of the antagonists was not influenced by the material ($p \geq 0.343$). Similarly, there are no differences in dressing resistance, since they were found between materials after a cyclical load with 20 N or 50 N ($p \geq 0.074$).

Within the limitations of this in vitro study, arylates for conventional subtractive and additive fabrication of occlusal deposits differ in material properties but not in resistance to wear and antagonist wear.

Regarding the article "Wear Resistance of 3D Printed and Prefabricated Denture Teeth Opposing Zirconia" [50], the objective was to evaluate the wear resistance of a recently developed three-dimensional (3D) printed dental prosthesis resin compared to three commercially available prefabricated prosthetic teeth.

A set containing 88 upper first molar prosthesis teeth was evaluated. The 3D printed denture samples were fabricated from a methacrylate-based photopolymerizing resin by stereolithography (SLA). The denture teeth were subjected to a three-body wear test with an abrasive slurry of poly (methyl methacrylate) (PMMA). A Leinfelder style four-station wear apparatus was used with custom bullet-shaped milled zirconia styli. The maximum depth of wear was measured using a laboratory grade scanner and analysis software program.

The conducted process allowed determining a statistically significant difference in the depth of wear between the materials of the teeth of the prostheses. The mean vertical depth of wear of the 3D printed prosthetic teeth (0.016 ± 0.010 mm) was statistically significantly lower than that of prefabricated prosthetic teeth. The highly cross-linked prosthetic teeth, DCL (0.036 ± 0.011 mm) and IPN (0.035 ± 0.014 mm), exhibited statistically significantly less wear than conventional acrylic prosthetic teeth. Conventional acrylic denture teeth showed the highest wear (0.058 ± 0.014 mm). No significant differences were found in the depth of wear between DCL and IPN ($p > 0.001$).

As a conclusion, it was established that the material of the denture significantly influences depth of wear. The 3D printed prosthetic teeth demonstrated superior wear resistance compared to commercially available precast prosthetic teeth compared to zirconia. Prosthetic teeth made with SLA technology may have a promising future in prosthetic dentistry.

VI. Conclusions

This research was developed with the objective of identifying different publications on additive manufacturing in dental pieces, in order to establish how much literature can be evidenced on this specific topic, and the advantages and disadvantages that can be found compared to subtractive manufacturing or traditional. From all this process, it was possible to determine the benefits for the dental health sector in terms of adaptability to the additive process, which generates advantages in terms of time, cost and customer satisfaction. Similarly, emphasizing on the improvements that can be achieved by adopting, for example, the new additive technology for manufacturing dental pieces. According to the systematic review, with adaptability to Prisma and Tranfield methodology, it is determined from Research and publications the impact of this modality on the processes performed in dental clinics and the implications for related professionals, who handle the dental pieces. In addition, the impact on the different clients who acquire these pieces in terms of taste and adherence to the product.

In terms of contribution to knowledge, the study could serve as a referent for other investigations to be conducted on this subject. This research contributes to the knowledge of the performed processes in additive manufacturing. A precedent is left for the adherence of this method.

Faced with the methodological development, the Q1 of citations by quartile were obtained when grouped by data, this allowed them to evaluate the importance in the scientific literature of each of them and to analyze them, thus finding that in 2020 their publications have proven to be the most representative, also the most updated.

According to the results found in the systematic review, with adaptability to Prisma methodology, it is concluded that within the study the characterizations considered being the most important and relevant, when analyzing the articles for the review, were type of impression, advantages / benefits and entry.

Additive manufacturing in dental pieces has great advantages, since its design and manufacture is adjusted to client's needs such as 3D-printable provisional restoration, since it allows having enough mechanical properties for intraoral use. However, despite the limited 3D printing precision for the chosen printing system, it is possible customizing the part precisely, which is a great advantage over another type of method.

Most of the published articles are experimental, which helps to recognize that post processes are conducted on each of the dental pieces, such as measurements of the original impression for an exact finish of the piece, the use of wear devices giving a better impression to the piece and test of resistance to the piece, among other aspects.

During the last five years, additive and subtractive manufacturing for creating dental pieces has been increasing, both for materials and for the types of impressions. This because of the fact that the technology is continuously updated, thus finding in this systematic review, the most used materials in recent times, such as ceramics, metals, resins, polymers, plaster, acid, cements. Related to printing types we have material extrusion (FDM), polymerization (SLA, DLP), powder bed fusion (polymers) (SLS) and powder bed fusion (materials) (DMLS, SLM, EBM).

For creating dental pieces, eventually, a single type of material and a single type of impression could be used. In other cases, two or more types of materials can be used and / or different types of impression could be used in order to finalize a tooth.

In subtractive manufacturing, the creation of dental pieces requires different processes, depending on the piece to be delivered. For additive manufacturing, it consists of a series of steps, which remains the same regardless of the piece that must be manufactured.

The number of post-processes for preparing dental pieces tend to decrease when additive manufacturing is involved, since in most cases the piece is ready to be placed on the patient. Subtractive manufacturing requires more post-processing, this because since in their creation their terminations are not precise, requiring a sequence of adjustments in order to be delivered according to the needs of the patient.

Therefore, each one of the aspects inherent to both additive and subtractive manufacturing has been indicated, regarding information and data found in the review and analysis of the articles that were established for the process in the systematic review with adaptability to Prisma and Tranfield methodology.

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