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3D PRINTING TECHNOLOGY IMPLEMENTATION FOR PERSONALIZED MEDICATION

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The unique properties of 3D printing technology, such as additive manufacturing, have been attributed to its growing demands in the pharmaceutical and medical device industries. In recent years, these technical approaches have gained in popularity as a cost-effective way to develop custom dose forms for tissue engineering and molecular diagnostics. A multimodal drug delivery system with faster release characteristics is being developed, which is useful in the case of personalized dose forms, according to an assessment of the existing situation. A review of 3D printing technology used throughout pharmaceutical applications was carried out. There are several kinds of 3D printers, and each one employs a unique technique to interact with different materials in diverse ways. In terms of material and application, the most crucial thing to keep in mind with 3D printing is that there is no one-size-fits-all solution. A light and heat source are sometimes used in 3D printers that employ powder materials to melt or fuse the layers of powder to create the desired shape. When using a 3D CAD (Computer Aided Design) file to make a 3D model or scanning a 3D object with a 3D scanner, the filament is heated by the extruder to form the layer and produce the desired shape

Key words: *3D Printing, Technology, Device, Pharmacy, Dose*

INTRODUCTION

The current scenario of medical treatment is centred on the paradigm "one size fits all" where most patients receive the same drugs at the same doses and frequencies as others. It came to light that this theory of "one size fits all" does not hold up in all treatments. Administration of the same active ingredient at the same dose to different individuals has shown varied responses. The response might be exaggerated and linked with adverse drug reactions (ADRs) or too weak, with insufficient or no pharmacological effects. Both these situations can be succeeded by adding patient complications[1]. This leads to the initiation of personalized medicines where medications are tailored to patients or designed more particularly for them as part of a group of genetically, physiologically or pathologically similar patients. With an aim of "one size does not fit all", its goal is to dispense the best drug at the best dose, for the precise indication of the patient, at the correct time. Personalized medicine promises more precise medications. These are safer and efficacious, improve patient compliance, and are cost-effective[2].

3-dimensional (3D) printing is one of the most conventional concepts and technology used for drug design. The 3-dimensional techniques are completely based on computer modelling and computer-aided design. To attain flexibility and save time consumed during the formulation and designing of a pharmaceutical dosage form with a high level of accuracy. It is entirely dependent on a deeper understanding of material properties and production technology, as well as the assurance of high dosage form accuracy and quality. The diversity of physicochemical and biological properties of API (Active Pharmaceutical Ingredient) must be evaluated and monitored at each stage of drug development, and additional auxiliary chemicals must be researched to produce the right dose form. In this process, drug

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components are formulated into the desired dosage form employing 3D photo typing of layer-by-layer fabrication via computer-aided design (CAD) models[3]. Within the recent decade, healthcare systems have been developed that can create a partnership between practitioners, patients, and their families to align decisions with the patient's wishes, needs, and preferences for medication product development. By combining a tailor-made artificial device used to replace a missing body component, such as a limb or a heart valve, with a small series of the specified dose form to meet the requirement of the patient[4].

In pharmaceutical formulation development, this methodology is gaining traction as a potential answer to some of the most pressing issues in traditional pharmaceutical dosage unit operations. The traditional pharmaceutical unit operations include milling, mixing, granulation, and compression, which can mean "different from one another; containing or made up of different and often incongruent elements" in terms of drug product quality such as drug loading, drug release, and drug stability in the final product. This completely depends on the stability of the final pharmaceutical product. So 3D printing is the most convenient and powerful technique used in the new era of formulation development. As it bypasses all the potential challenges that occurred during the formulation and designing of new pharmaceutical dosage forms[5]. 3D printing is already one of the most meliorating technologies in art and science, but it is also finding applications in other fields. The term "object fabrication using material deposition employing printing heads, nasals, and other printer technologies" was coined by the International Organization for Standardization (ISO). Additive manufacturing (AM) is a type of formative and subtractive technology in which distinct parts are generated by 3D modelling and then joined together layer by layer. It is a very fast and accurate method. Rapid Prototyping (RP) is a practical technique for additive manufacturing that has the advantage of reducing prototyping time and cost and facilitating particle modification at the design level. As a result, we will examine all aspects, obstacles, and opportunities of 3D printing, as well as its application, in this paper[6]. Chuck Hull created the SLA which was based on the photopolymerization of liquid resin by ultraviolet light[7].

Children seem to be the most difficult of the population to satisfy because of their individual preferences when it comes to the dosage form, taste, shape or smell. Oral delivery might seem to be the most convenient but might become rather complex when it comes to children. A child may simply reject a dosage form or another because of minor attributes such as preferences in shape, colour or taste. This is where 3D printing can come in and tend to their individual choices. A major concern in treating children is the administration of adequate doses according to the body weight, which can be solved using 3D printing, as mentioned above[8-10].

Swallowing being a concern in smaller children, fast disintegrating tablets and mini-pills fabricated by 3D printing seem to be suitable for administration. A study highlighting the dosage form preferences in children concluded that children preferred mini-tablets of 4 mm diameter over other formulations. Medication adherence and compliance in children can be increased by giving them dosage forms in a flavor and colour of their choice. Apart from printing the tablets in different doses as per the requirements, they successfully printed tablets in various flavors (lemon, coconut, banana, raspberry, etc.) and colours (yellow, black, light green, orange, etc.) which were well accepted by pediatric patients according to their preferences. Another study successfully fabricated children-friendly chewable chocolate-based dosage forms in various shapes[11].

In most of the geriatric population, swallowing tablets becomes a major challenge which can influence medication adherence as swallowing difficulties increase with advancing age. This can be resolved by using fast disintegration tablets and orodispersible film formulations which can be fabricated by 3D printing as mentioned above. The older population suffers from multiple ailments and requires multiple drugs and prolonged medication which brings in the issue of polypharmacy. Polypharmacy can be resolved by the means of poly-pills fabricated according to the patient's need by 3D printing. Some of them also suffer from cognitive impairment (dementia) which can affect medication adherence. This can be resolved by using 3D printed dosage forms with embossing designs on them which can indicate the time of administration, date, and/or weekday for administration, customizable to each patient[12].

Visual impairment affects about 285 million people worldwide and this leads to several concerns when it comes to medication and treatment, especially in the older population who are dependent on multiple medications. This leads to poor medication adherence and treatment management which would eventually lead to therapeutic inefficiency. Tablets of various shapes were developed which offered added information like medication indication or dosing regimen. This innovative concept can aid the treatment of visually impaired patients greatly by improving medication adherence and reducing medication errors[13].

History

3D printing technology was first used in the late 1980s when it was referred to as rapid prototyping (RP) technology. In actuality, the first patent for stereo lithography equipment was issued in 1986, and 3D printing has been around since then Stereo lithography apparatus (SLA). Because he first created his SLA machine in 1983, Charles Hull is the inventor who owns this invention. Hull continued to work for 3D System Corporation, which is now one of the largest and most productive 3D printing companies in the world[14].

In 1990, 3D printing created a platform for individualized treatment[15]. The first 3D printing approach in pharmaceutics was inkjet printing, which involved spraying a binder fluid over a powder bed to bind the particles collectively. This technique was maintained until the appropriate structure was attained, which happened for the first time in the early 1990s at the Massachusetts Institute of Technology[16]. Spritam (levetiracetam) tablet was the first 3D printed drug approved by the FDA in 2016, and it was an oral tablet produced and used inkjet printing technology[17].

How the 3D printer works

There have been various types of procedures that have been improved and changed with the technical process during the past 40 years of 3D printing history. The main three methods were based on:

a. Powder solidification
b. Liquid solidification
c. Extrusion

Despite a variety of 3D printing methods, the development of 3D printing objects includes the following stages see, (Fig. 1). To design the 3D printed object with computer-aided design software should be optimized for geometry according to the printer description. To explore the 3D model to a common printer there should be a detectable file format. Import the file to the software and creation of the layer to be printed the height of the printed layer specifically can influence the quality of the printed object followed by its printing time. For modelling of an object by subsequent application of material layers, they are committed with a specific printing method.

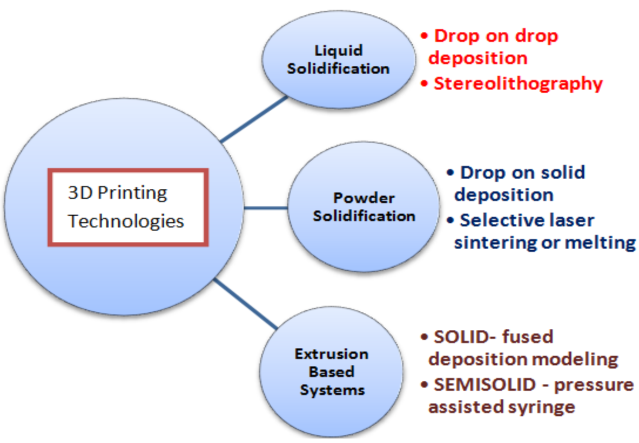

Fig. 1: Different stages 3D printing technologies.

D Printing Method Applied for Drug

Each 3D printer operates in a particular mode, which necessitates the solidification of sufficient material and subsequent object production.

There are various types of 3D printers, each of which uses a distinct technology to work with various materials in different ways. The most important thing to remember about 3D printing is that there is no one-size-fits-all answer in terms of material and application. Some 3D printers work with powder materials and use a light and heat source to melt or fuse the layers of powder to achieve the desired shape. In the case of a 3D CAD file for use in generating a 3D model or scanning with a 3D scanner in the filament, which heats the extruder to create the layer and achieve the desired shape. Because the parts can be printed directly, it's critical to create incredibly intricate and elaborate things that can be used to build and eliminate the need for assembly[18]. Although software for layer-by-layer printers undergoes continuous changes and upgrades, this aids in the creation of a dominant shape with improved features in a variety of settings. Furthermore, several parts will be required for finishing operations once the printer has been turned off. Others, on the other hand, need expertise, time, and patience since they require hand sanding, painting, or other traditional final touches. The item will become more visible shortly. After the printing process, we will have the desired object.

Advantages

- It avoids batch-to-batch variances that are encountered in bulk manufacture of conventional dosage forms, and it has a high drug-loading ability when compared to conventional dosage forms.
- It takes up little room and is inexpensive.
- Because of small material waste, it lowers production costs.
- Based on a patient's age, gender, genetics, ethnicity, and environment, medication can be personalized to their specific needs.
- Manufacturing in limited quantities is possible, and the process can be completed in a single run. The variable design and manufacturing of this dosage form allow for the integration of immediate and controlled release layers, which aids in the selection of the most appropriate treatment regime for the person.
- Accurate and accurate dosing of a drug given in a little amount.
- Treatments can be changed in multidrug therapy with multiple-dose regimens to increase patient adherence. It has limitless possibilities in the development of patient-specific drug delivery devices (DDDs) and dose forms.
- As a result, technological advancement is in the works. However, as research on 3D-printed DDD has progressed, we've been able to identify several problems connected to the manufacture and commercialization of individualized drug delivery systems.
- Manufacturing is now possible thanks to 3D printing technology prototypes of DDD which have varying complexity has shown that the customization of the drug product is possible[19].

3D printing is a unique prototyping technique that has been developed over more than 35 years and has the potential to revolutionize the field of medication delivery due to its inherent benefits of customizability and the capacity to build complex solid dosage forms with great accuracy and precision. It may produce solid dosage forms with a variety of densities, complex internal geometries, and a wide range of medicines comprising excipients. 3D printing can successfully address drug delivery of poorly water-soluble medicines, peptides, and potent pharmaceuticals, as well as the release of medicines employed in the treatment[20].

Technique For 3d Printing Technology

Manufacturing of 3D printing can be achieved by no. of techniques[21] such as:

a. Inkjet based fabrication
b. Zip dose
c. Stereo lithography printer (SLA)
d. Fused deposition modelling (FDM)
e. Selective laser sintering (SLS)

When compared to traditional pharmaceutical manufacturing processes, 3D printing offers a wide range of appealing properties, including the following:

a) Having a quick operating system and a high output rate.

b) The ability to obtain high drug loading more reliably, particularly for strong medications that can be administered in tiny doses.
c) This aids in the reduction of material waste, which lowers production costs.

The 3D printer in pharmaceutical drug delivery can predict better and broadly in the area of personalized medicine[22]. As we all know, pharmacy has progressed to the point where one size does not fit all. As a result, medications should be tailored to the specific needs of each individual, considering differences in genetic profile, age, gender, epigenetic and environmental factors[23-26].

Fused deposition modelling (FDM)

Modelling, prototyping, and production are all popular uses for this manufacturing method. By laying down materials in layers, it works on an additive approach. Metal wires or plastic filaments are wound up with a coil, and the material is extruded to an extrusion nozzle, which controls the flow on and off, as indicated in the diagram as shown in (Fig. 2)[27].
This nozzle is heated to melt the materials, which may then be manipulated vertically and horizontally by operating a software package called CAM (computer-aided manufacturing). The part is made by compressing small beads of thermoplastic materials to build layers, and the materials solidify instantly after being extruded from the nozzle. The extrusion head is moved by two motors, one of which is a stepper motor and the other is a servo motor. Fused deposition modelling is a popular type of rapid prototyping that may be used for both prototype and manufacturing[28].

Zip Dose

SPRITAM, the first FDA-approved 3D printed pill, was created using Aprecia's patented zip dosage technology platform. Developing cutting-edge technology that employs 3D printing to create a permeable composition that dissolves quickly with just a sip of the drink. It is possible to give a high medication load of up to 1000mg in a single dose using zip dose technology. With only a sip of fluid, SPRITAM improves the patient experience by providing the highest strength of levetiracetam. Aprecia employed the Massachusetts Institute of Technology-developed 3D printing technology[29] to create its ZIP DOSE technology platform. The layer-by-layer powder bed fusion technique underpins this zip dosage technology. The first layer contains active pharmaceutical ingredients (API) that are necessary for matrix tablets, followed by a binder liquid that is deposited to ensure flawless combination and aggregation amongst all subsequent and identical layers[30].

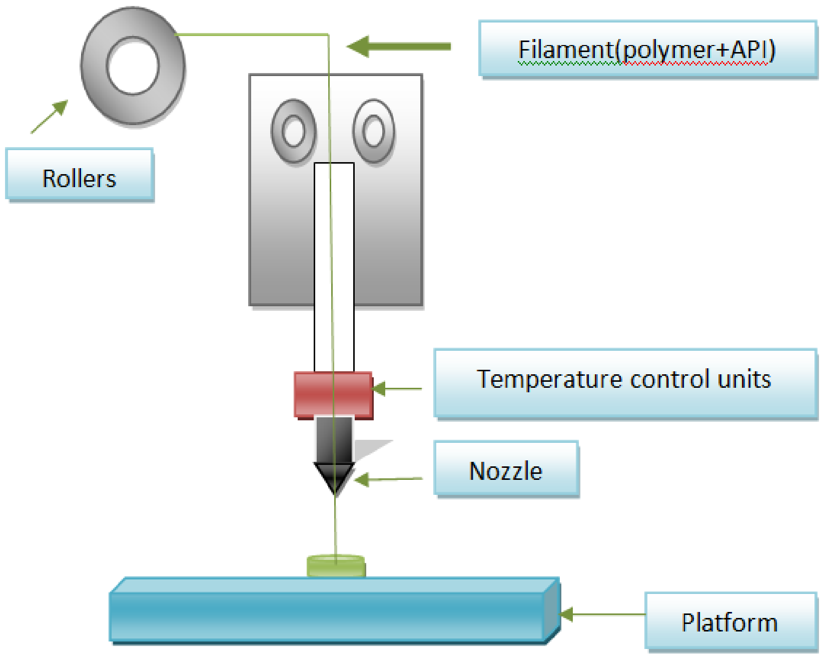

Fig. 2: Fused deposition modelling (FDM) printing system.

Inkjet Printer

This customized medicine strategy is based on the same computer-operated inkjet printing technique that has been updated for pharmaceutical uses by replacing the ink with a medicinal solution. This comprised the medications as well as regular paper with an edible substrate sheet[31]. The most essential aspect of this sort of printing is dose adjustment, which is accomplished by adjusting or changing the area to be printed or increasing the number of layers printed in a certain place. The pharmaceuticals and recipients are formulated in such a way that they can be published as microdots on an edible substrate in this method. Thermal inkjet printers and piezoelectric inkjet printers are the two main printing technologies used in inkjet printers[32]. Inkjet system-based printing is bounded by 2 types of techniques-

Drop-on-demand printing (DOD)

DOD- This technology uses numerous heads (100-1000), each of which can employ either a thermal head or a piezoelectric crystal as a translator. The thermal head is confined to volatile liquids, whereas the piezoelectric head can handle a wide range of liquids.

As the temperature of the thermal heads rises, they approach 300°C, preventing the use of high vapour pressure solvents, which can degrade bioactive substances[33].

As a result, thermal printing heads for pharmaceutical applications are both a consideration and a limitation. There are two types of DOD techniques.

1. Drop-on-drop deposition (Fig.3)
2. Drop on a solid deposition. (powder bed fusion).

As a result of inkjet printing, we can achieve precise control of dose combination and medication release pattern. The formulation of a larger dose with this type of technology can result in issues such as long drying times when printing numerous layers on a single region. As a response, to address this issue, an increase in surface area was implemented, resulting in a larger dose form[34].

Continuous inkjet printing (CIJ)

The liquid ink is induced to flow and break into defined speed and size drops at regular intervals through an aperture of 50-80m diameter using a piezoelectric crystal, resulting in a continuous ink flow. Establishing an electromagnetic current regulates all of these parameters, which charge the droplets and separate them with guard droplets to reduce electrostatic repulsion. The charged droplets are created and controlled by electrostatic fields.

Stereo lithography printer (SLA)

It is a preservation manufacturing technique in which Pieces are manufactured one at a time using an ultraviolet laser from a container of liquid containing UV-curable photopolymer or resin. As shown in the illustration, the laser beam identifies the cross-section part and pattern on the surface of the liquid resin for each layer (Fig.4).

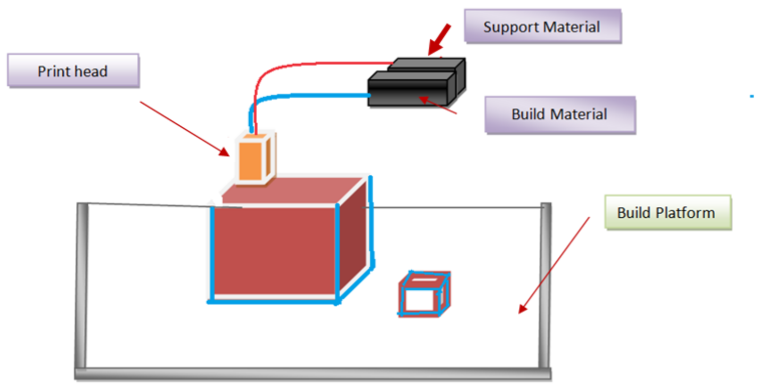

Fig. 3: DOD deposition technology.

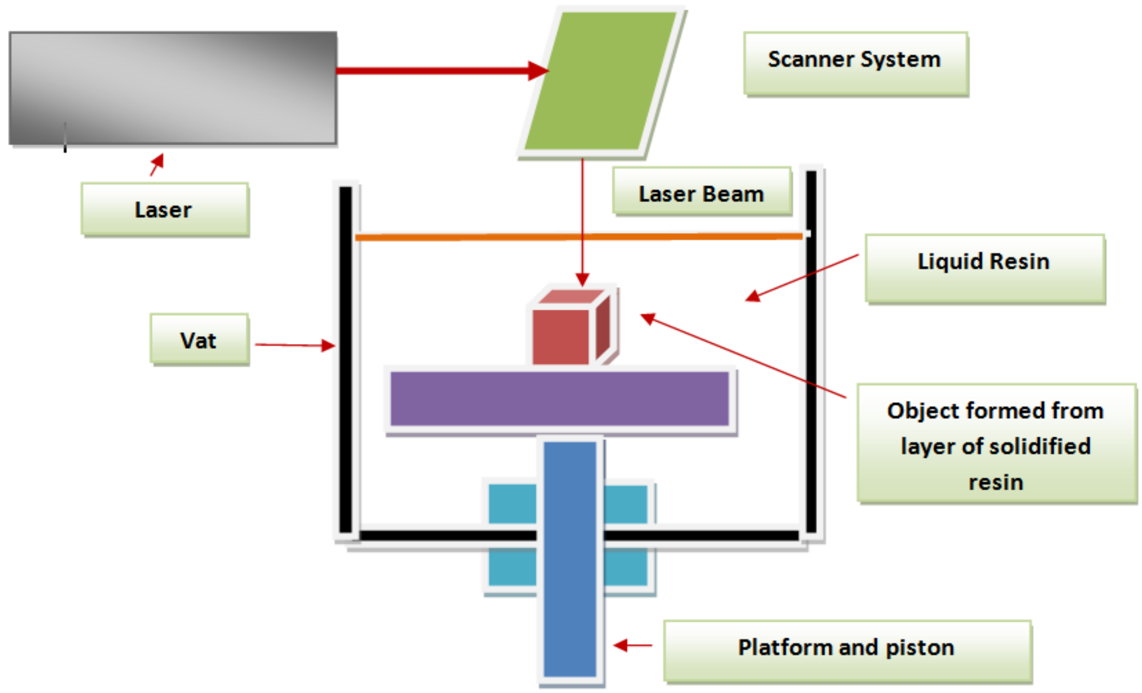

Fig. 4: Stereolithography (SLA) printer.

The patterns that are identified on the resin are restored and solidified using ultraviolet laser light, which joins it to the layer below. This method includes producing a 3D structure by scanning a concentrated UV laser over the top of a photo-polymerizable liquid layer by layer to demagnetize photosensitive components (photopolymerization). SLA triggers a chemical reaction in the photopolymer that used a digital mirroring device, resulting in gelatin of the exposed area. To create the complete part of the object, the same technique is performed layer after layer[35].

UV light in the form of a laser is used in SLA printers to convert energy into a liquid photo-polymerizable resin. This UV beam is guided across the surface of the liquid resin by baffles on the X and Y axes for a perfect depiction of the 3D model. They have automatically supported the production of 3D computer-aided design models for use with stereographic machines, even though they can be manually altered, unlike less expensive, rapid photo typing technology. Its key advantage is the rapidity at which a working item may be made in a day.

The time it takes to develop a path is dictated by the complexity and scale of the project, and it can take anywhere from a few hours to more than a day. The stereolithography prototype is tough enough to serve as a master pattern for injection moulding, thermoforming, blow moulding, and other metal casting techniques. They can also be used to make a variety of forms[36].

Selective laser sintering (SLS)

It is a technique of additive manufacturing that includes using a high-powered laser to fuse minuscule particles of plastic, metals (Direct metal laser sintering), ceramic, or glass powder into a mass with a specified three-dimensional structure (such as a carbon dioxide laser). By scanning a cross-section obtained from a 3D digital description, the laser preferentially mixes the powder material; CAD files scan the data into the powder bed's surface. When the scanning of the cross-section is complete, the powder bed is lowered due to the thickening of one layer, and a subsequent layer of material is applied on top, and the process is repeated until all of the parts are completed. Because the density of produced components is influenced by peak laser strength rather than laser duration, the SLS machine uses a pulse laser. In SLS machines, two-compartment powders that are either coated or a powder mixture is commonly used. The laser only melts the particle's external surface in single-compartment powder, a process known as surface melting, resulting in the fusing of solid non-melted course within them for the previous layer[37].

Geometry Consideration

The shape of prints also influences the dissolution rate of the drug. As paracetamol tablets with different shapes and the constant surface were preferred by Goyanes et al, Because of their larger surface area/volume ratio, the pyramid shape formulation produced the fastest dissolution rate. The slowest dissolution ratio, on the other hand, recognized cylindrical and spherical shapes with a smaller surface area/volume ratio. As a result, adding more channels to the tablet design was recommended as a way to speed up hydrochlorothiazide disintegration. During the design process, a cross-section channel with a diameter ranging from 0.2 to 1.0 mm was introduced to balance the cross-section. The dissolution results revealed that channels with a diameter of less than 0.6 mm were essentially speeding up the drug release, meeting the pharmacopoeial criteria for an immediate-release product. Arafat et al. presented a different strategy for tablets. The tablets were made up of bridging 9 pieces with spacing gaps in this method. The disintegration and dissolution time was influenced by the difference in block and gap size. As a result, the proposed method offered an intriguing alternative for using disintegrants to speed up the breakdown of tablets[38].

Patient-Centric Therapy

Because of the wide range of materials available, 3D printing has a wide range of applications in the medical field. For example, it can be used to build a spatial system using tissue engineering and pharmacy to prepare the same dosage form as a tablet[39], capsule, implant or orodispersible films[40]. All of these drugs may be made in a variety of shapes, and only a handful of them have a single API that can be produced on a large scale. However, while the concept of individual pharmacotherapy has been around for a long time, its significance has never been larger than it is now. Because The heterogeneous nature of diseases is a source of therapeutic incursion, necessitating the development of personalised medicine with the assistance of rational use of the drug by the patient in the right dose, which is a hot topic of debate. Modifications of dose form, as well as dosing of the active substance for each age group, are done for a variety of reasons, including therapy failure or therapeutic effect limitation[41].

As a result, the optimal dose form must be chosen not only based on physicochemical features but also the target population and disorders being treated. The need for pharmaceutical product development for the geriatric and pediatric population was specifically recommended due to the diverse needs and characteristics of each patient group due to their dose flexibility and differences in swallowing pattern, tablets were subdivided into two or even four parts, which were a common practice done by health care sectors. The problem with this type of tablet was first noticed when it began to break unevenly and lose mass, eventually leading to over-or under-dosing. To address all of these issues, 3D printing could be immensely beneficial in the creation of tailored therapy. By adjusting the dose and dosage form, 3D printing enables highly personalized treatment based on the patient's body weight and lifestyle[42].

Biomedical Application

Since the development of 3D printing in the late 1980s, there has been a significant increase in the influence of additive manufacturing techniques on the biomedical profession. Because technique allows for the creation of It has evolved into a powerful tool for biomedical engineering, allowing for the creation of manufacturing implants that fit patient-specific anatomy in the context of education, surgical planning, and disease models with highly customized architecture and functionalities. On the other hand, additive manufacturing is taken from nature and results in the development of a smart material or gadget[43].

Wound dressing

The growing need for custom-made functionalized materials has fueled the development of additive manufacturing structures. In the case of Nano-technological techniques, it is clear that there are numerous obstacles that current medicine has neglected; nonetheless, the safety of their application is still being investigated. Although these methods were touted as antibacterial nanoparticles and their carriers, a factor in improving wound healing, which is difficult for industrial applications, a new challenge has arisen in the field because their approach is competent to manufacture a customized and safe material with sophisticated planning and functionality; additive manufacturing is a feasible alternative. The patient-specific antimicrobial wound dressing is manufactured from polycaprolactone (PCL) with integrated zinc, copper, and silver. Using hot-melt extrusion, a metal with uniformly loaded filament was obtained, and 3D models of the nose and ear were created. As a result of the wound dressing demonstrating the prolonged release of various metals and their bacterial properties, anatomically adaptive dressing was stopped before the more costly traditional flat dressing. The matrix was designed to improve wound healing in vascular grafts that allowed for the replacement of injured artery wounds following surgical repair utilizing a 3D printed hybrid scaffold made of polyethene glycol (PEG) and homogenized pericardium. The addition of homogenized pericardium to the PEG matrix modified the modulus of the scaffold and reduced macrophage inflammatory signals. In terms of vascular graft development, the biomaterial created was thought to be very promising, opening up a new avenue in congenital heart defect and reconstruction[44].

Implants and prostheses

The additive manufacturing of prostheses and implants has reshaped the field of designing a medical device that meets the demand for tailored therapy. 3D printing enables the creation of custom-made products that meet the needs of particular patients as a result of their anatomy and physiology. It also allows for structural and temporal control of bioactive chemicals, as well as the evolution of structure with site-specific mechanical and physical properties. Custom prosthetic fitments and devices allow for the restoration of mobility and function as well as the restoration of a normal appearance that has been lost due to deformation. Herbert and coworkers[45] created boots to overcome this prosthesis. According to the author, 3D printing is a simple and practical technique for creating prosthetic sockets, which patients found pleasant after implantation. Another example is Zuniga, an innovator who created a low-cost 3D-printed hand for children with upper-limb deficiencies[46]. A poll found that prosthetics can improve one's quality of life and can be used for a variety of activities at school and at home. As the cortical exoskeleton cost was built by Jack Evill, it has been discovered that the 3D printed structure aids the patient in strengthening and speedier recuperation after a bone fracture. This orthopaedic device was made of nylon mesh and was light, sturdy, and breathable, with the most crucial feature being that it was water-resistant[47].

Because unique face features may be precisely duplicated, additive manufacturing is given special attention in the field of craniofacial reconstructive surgery. This has a significant impact on the aesthetic issue and physical appearance. Replacement with silicone prosthesis or patient's cartilage is available for congenital malformations of the ears, although these are far more expensive and require multiple visits to the hospital. However, obtaining a form that properly matches the defective region without the use of healthy tissue fillers is quite challenging[48].

Craniofacial plastic surgery

After treating more than 500 cranial instances with 3D printed tactile prototype models, researchers discovered the potential application of 3D printing in the field of craniofacial surgery. In a variety of medical sectors, craniofacial plastic surgery is one of the key areas where 3D printing is being used.

Skull reconstruction

For rapid prototyping (RP) models, a calvarial bone repair can be used. Mankovich et al. were the first to use 3D technology to achieve this skull reconstruction in 1994. The donor bone should be obtained since autogenously bone grafting may be a better standard for skull repair. However, because bone is a highly hard product, bending is difficult and dangerous; the appropriate curvature should be researched in advance. Physical prototype models have been found in recent research to be highly helpful in identifying the best donor for the job[49].

Facial bone fractures

However, while 3D printing technology may treat a variety of facial bone fractures, orbital wall fractures are the best candidates for this treatment. The reason for this is that the orbit has a complicated architecture, making optimal rebuilding difficult. Postoperative enophthalmos or diplopia will occur unless the orbital wall is repaired precisely. Even though 3D printing techniques have long been used in craniofacial surgery and are based on extensive experience with 3D printing in craniofacial repair[50].

Human Skin

The greatest portion of the human body, according to human anatomy, is the skin, which plays a critical function in maintaining homeostasis and providing protection from the external environment. Skin's highly complex, layered, and hierarchical structure provides a physical barrier for xenobiotics to enter the body while also managing the passage of water and tiny metabolites out[51]. In essence, a wound caused by physical or chemical stress compromises the skin barrier and inhibits physiological function. In cases when a significant amount of skin has been lost due to traumas, it becomes critical to replace damaged skin with grafts to prevent water loss from the body. Skin grafts, on the other hand, can lubricate the wound healing process to an excessive degree, as well as restore the barrier and regulatory function at the wound site[52].

Heart valve

Prosthetic valve replacement is the most common treatment for heart valve disease, which is one of the most important and rapidly expanding health problems in the population. Recent prosthetic devices, on the other hand, are only suitable for younger people and growing youngsters[53-55]. Moulding a valve shape from biodegradable scaffold materials and including it within the cells and cultivating it in vitro under dynamic simulation was a common production approach for circumventing these restrictions. A huge number of synthetic fibres and natural biomaterials were used to create 3D heart valve scaffolds before implantation. To manufacture a complex tissue construct, 3D bio-printing uses rapid prototyping processes that follow a computer-assisted manufacturing design[56-58].

Limitations and Challenges

However, various limitations limit the use of 3D printing in commercialized market problems, such as the selection of appropriate binders, recipients, and final product pharmacy technical qualities. However, to overcome these challenges, more progress in performance and procedure is required, where 3D printing technology can be successfully integrated with a revolutionary medication delivery system[59-62].

3D printing encompasses a variety of techniques, each with its own set of benefits and drawbacks, such as powder solidification, extrusion, and stereo lithography, which have been used to manufacture medicine items. The most significant obstacles to the use of personalized pharmacologic therapy are more or less regulatory issues involving the implementation of a production model that can efficiently convert small batches of acceptable medicinal items that meet predefined quality standards to meet the therapeutic needs of an individual patient[61]. However, proving that 3D-printed medicine has the same efficacy, safety, and stability as traditional pharmaceuticals remains a difficulty. By reading the laws and established criteria for quality system safety, it becomes clear that the use and consumption of 3D printed medicine pose additional issues for regulatory authorities, posing significant impediments not previously seen in the pharmaceutical industry[63-65].

Conclusion

3D printing has become an important technology in the pharmaceutical industry, allowing for personalized treatment that is tailored to the individual needs of patients. Because fast prototyping may be done in a matter of minutes, it has various advantages, including increased cost-efficiency and manufacturing speed. However, ensuring that 3D printed medicine has the same efficacy, stability and safety as offered FDA with introductory thoughts on technical issues relating to the additive manufacturing process, as well as a recommendation for testing and characterizing devices that incorporate at least one additive manufacturing fabrication phase.

"The revolution in medication production processes is only getting started".

Future Prospective

By focusing on the aforementioned characteristics, 3D printing will undoubtedly transform the way pharmacy operates. Because the printing of tissue and viable organs can be utilized in toxicity testing and drug research, each patient may be able to print their prescription, which may sound like something out of a science fiction novel, but we're closer than we think.

List of Abbreviations

3D	=	3 Dimensional
API	=	Active Pharmaceutical Ingredient
CAD	=	Computer-Aided Design
AM	=	Additive Manufacturing
RP	=	Rapid Prototyping
SLA	=	Stereo lithography apparatus
FDM	=	Fused deposition modelling
SLS	=	Selective laser sintering
CAM	=	Computer-Aided Manufacturing
DOD	=	Drop on-demand printing
CIJ	=	Continuous inkjet printing
PEG	=	Polyethylene Glycol
PCL	=	Polycaprolactone
DDD	=	Drug delivery devices
FDA	=	Food and drug administration
ISO	=	International Standard Organization

Declarations

Conflict of Interest

The authors declare no conflict of interest, financial or otherwise.

Research Involving Humans and Animals Statement

This review does not contain any studies with animal/human subjects by any of the authors.

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تطبيقات تقنية الطباعة ثلاثية الأبعاد للأدوية المخصصة

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ترجع الخصائص الفريدة لتقنية الطباعة ثلاثية الأبعاد مثل تصنيع المواد المضافة إلى الطلب المتزايد عليها فى الصناعات الصيدلية والأجهزة الطبية . وفى السنوات الأخيرة أكتسبت هذه التقنية الجديدة المزيد من المعرفة كطريقة فعالة من حيث التكلفة لتطوير أشكال جرعات مخصصة لهندسة الأنسجة والتشخيص الجزيئى . ويتم تطوير نظام توصيل الأدوية متعدد الوسائط بخصائص إنطلاق سريعة وهو أمر مفيد فى حالة الجرعات المحددة . وتم عمل سمح شامل فى هذا البحث المرجعى لمراجعة تقنية الطباعة ثلاثية الأبعاد التى استخدمت فى جميع التطبيقات الصيدلية . ويوجد عدة أنواع من هذه التقنية وكل واحدة تستخدم أسلوبا فريدا للتعامل مع المواد المختلفة بطرق متنوعة . وفيما يتعلق بالمواد والتطبيق فإن أهم شيئ يجب مراعاته فى هذه التقنية أنه لايوجد حل واحد يناسب جميع الحالات . وقد تم إستعمال مصدر الضوء والحرارة فى هذه التقنية التى تطبق على المساحيق لإذابة أو دمج بعض طبقات المسحوق لتحضير الشكل المناسب المطلوب الوصول إليه . وعند إستخدام برنامج (CAD تصميم بمساعدة الكمبيوتر) ثلاثى الأبعاد لتحضير نموذج ثلاثى الأبعاد باستخدام ماسح ضوئى يتم تسخين الإكسترودر لتشكيل الطبقة وتحضير الشكل المطلوب .