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Review of Orthopaedic Additive Manufacturing Applications

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ABSTRACT:-

Background: In the field of orthopaedics, the use of additive manufacturing (AM) has significantly risen. The applications of AM include the creation of anatomical models, the design of surgical instruments and tools, splints, implants, and prostheses. A quick assessment of several research articles reveals that patient-specific orthopaedic procedures have a wide range of applications and point the way for new paths in the field. This study aims to determine the optimal applications for additive manufacturing in the field of orthopaedics. It also describes how to prepare a 3D printed model utilising this technology and provides information on orthopaedic applications. In the field of orthopaedics, AM offers a versatile solution that enables the replacement of standard goods with customised ones and allows for the formation of specialised implants in the desired shape and size. With the aid of this technology, a 3D model of the patient's anatomy is built, which is utilised to do mock operations and is beneficial for extremely difficult surgical diseases. It raises the success rate of the procedure and makes the surgeon's job more accessible. A precise fit implant for the individual patient is made possible by AM's limitless geometric freedom. The condition of bone deformities is captured using a variety of scanning methods, and the model is printed with their assistance. It provides accurate physical model generation that is also beneficial for medical education, surgical planning, and training. As each patient's data is unique, this technology can assist in resolving current issues.

Keywords: Applications, 3D Printing, Additive Manufacturing, Customisation, Simplant, medical, orthopaedics.

INTRODUCTION: -

Researchers have looked into the potential uses of additive manufacturing in a number of technical and medical specialties as a result of recent significant advancements in the field. It converts a digital 3D model into a physical model without the need for process design, actual tools, or dies. With a variety of materials, including nylon, plastics, and even metals, this technology has a significant capacity for fabricating complex shape prototypes. It creates biocompatible implants that adhere to structural specifications.

To create a 3D model from a Computer Aided Design (CAD) model, additive manufacturing uses materials like powder, plastic, or metal that are applied one layer at a time. This process

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differs from standard manufacturing technology in that it layers materials on top of one other rather than removing material. Through the use of this technology, complex disease and the patient's anatomy can be better understood in surgical applications.

It is simple to develop individual custom implants and patient-specific tools that aid surgeons during patient surgery. Orthopaedics is a surgical specialty used in biomedical engineering through a variety of specialties, such as joint arthroplasty, spanning from trauma surgery to tumour surgery for the treatment of the deformity. Applications in orthopaedics offer a thorough examination of craniomaxillofacial surgery and the musculoskeletal system. Applications of additive manufacturing provide a versatile alternative for producing surgical equipment and implants quickly and affordably while maintaining excellent patient-specific quality. AM has a number of advantages over traditional implant manufacturing techniques. Patient-specific pieces are generated using 3D CAD data without the use of any tools, utilising the necessary medically acceptable materials, and with a high degree of accuracy and precision. It simplifies the surgeon's task and optimises the patient's therapy with the fewest negative side effects possible. Individual instruments can be produced using AM techniques, and different medical equipment can be produced with ease. The utilisation of bioactive materials and polymer to quickly construct implanted devices is reshaping orthopaedic care.

Creation of 3D items using orthopaedic additive manufacturing applications

To gather correct medical imaging data for each patient in orthopaedics, a patient-specific analysis is crucial.A 3D picture of the patient's anatomy can be prepared quickly and cheaply using magnetic resonance imaging (MRI), current multi-row detector computer tomography (MDCT), computed tomography (CT) scan, X-rays, and 3D scannersAdvanced medical imaging captures the data, which makes the diagnosis accurate and easier to handle.These scanning methods' 3-D reconstruction images offer enhanced visualisation [14, 15]. This offers more accurate diagnosis and better surgical management. These scanning technologies produce 3D images that are seen on a computer screen but cannot alter how a real model is perceived in complex situations. To fully grasp this, it is required to create these 3D models using additive manufacturing techniques. The surgeon has access to superior information thanks to these 3D printed models. To finish the printing process by 3D printing machines, it is important to prepare DICOM, which is taken from the medical imaging, and then convert it into STL format.

Orthopaedic applications of additive manufacturing

Researchers are currently looking into its uses in many medicinal domains. The first objective of the 3D printed model is to mimic the cases in the clinic and provide the surgeon with a thorough overview. This model's primary use is during the testing process since it gives the surgeon a sense of the mechanical response of actual bone. Before executing the real surgery, the procedure can also be examined and visualised on the 3D model. In comparison to

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conventional surgical approaches, the use of additive manufacturing in orthopaedic surgery results in reproducible, safe, and reliable models that enhance patient outcomes and shorten operating times. For preoperative planning, education, and custom manufacturing, this technology can be effective. It is utilised for implants, surgical guides, and prosthetics in custom manufacturing applications. Students, trainees, patients, and surgeons have benefited from 3D printed models of the human body in their education. Surgeons and other medical professionals can use 3D printed bone models to practise surgery and teach patients or students about the procedure. Additionally, it might make it easier to redesign and provide the surgeon access to more tools. It develops into a useful tool that affects all facets of medicine. Now, surgeons can create novel surgical instruments and approaches.

DISCUSSION :-

Orthopaedics benefits significantly from the easy development of personalised implants and prostheses made possible by additive manufacturing. This method allows for the quick fabrication of implants in any desired shape as well as the creation of size-variable micro-pore architectures. It is encouraging for the investigation and development of orthopaedic implants. Its applications in medicine are improved, and they address numerous issues in this area. Surgeons who use 3D printed physical models can better visualise and feel the disease and anatomy specific to a patient. With a real 3D physical representation, both the surgeon and the patient may now clearly grasp the medical issues. It improves patient safety and satisfaction. To help doctors and medical students comprehend the many forms of fractures, training is beneficial. Orthopaedic standards for customised, high-quality implants made from a variety of materials are promptly constructed with the least amount of danger. This approach tends to make the implant lighter by altering the qualities of the raw material. It provides a flexible solution by producing different medical instruments and gadgets quickly and affordably.

Limitations and foreseeable future

The cost of using additive manufacturing technology is highly high and includes the price of printing materials as well as the cost of the software, gear, skilled labour, and upkeep. Implants are made by AM at a high cost, and designing them is similarly expensive. The length of time it takes to produce physical models is another restriction of this technique. It is a variable that is based on the size and complexity of the model. It takes time to acquire images and process data. Then, for model fabrication, it depends on the different additive manufacturing technology kinds. The machines need 24 hours to finish printing the regular model. This technology's use of printed models is limited. In some instances, it is not put into practise and is simply useful for gaining a better understanding of the procedure itself. Orthopaedic implants created using additive manufacturing (AM) technology are built layer by layer and then joined. It may not always be possible to produce the mechanical strength that the user requires, making it inappropriate for prolonged usage.

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Future patients may benefit from bespoke implants that were 3D printed. Artificial bone has similar mechanical characteristics to those of human bone. It creates a possibility for reconstruction that benefits orthopaedic surgeons, radiologists, and implant businesses.A surgeon can facilitate customised patient treatments for their patients by using this technology. It opens up new possibilities in orthopaedics for accurate physical model development that is also good for instruction, surgery planning, and training. The fact that each patient's data is unique means that this technology can address current medical difficulties.It allows for easy communication between various healthcare professionals. This may provide elastic qualities and strength that are similar to those of bone. Prior to the procedure, it created the implant of the necessary size and shape, which enhances the patient's surgical experience. It contributes to improving the patient's long-term quality of life.

CONCLUSION:-

A sort of manufacturing technology called additive manufacturing creates a 3D object from a digital model. A bone prototype can be created using a layer-by-layer process using a 3D reconstruction of the bone using CT and MRI data. This technique is useful for both medical and orthopaedic surgery. This is beneficial for the presentation, teaching, and planning of difficult operations. A bone that is missing a piece can be constructed utilising the reverse engineering method of AM. This technology is becoming more and more popular for preoperative surgery planning, tissue engineering, implant design and fabrication, and even medical student and surgeon training. As opposed to regular implant manufacturing via the conventional manufacturing procedure, it quickly generates an implant of the specific patient that fits better.The surgeon is able to comprehend more because to the accurate physical model that this technology produces. Another use of the method utilised to create structurally complex bioscaffolds is the creation of scaffolds for bone tissue engineering. 3-D bio-scaffolds are created with considerable mechanical and biological qualities to meet the demands of clinical applications.Surgery is made easier and more precise with the use of 3D printed surgical guides. In order to make surgery successful, additive manufacturing technologies are employed in conjunction with CT and MRI scans to collect data.

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