CUSTOMIZABLE 3D – PRINTED HIP BRACE FOR FEMORAL NECK FRACTURE

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Abstract- The need for organ repairs, tissue regeneration, and replacement is growing among individuals with diseases or damaged bones, such as those experiencing hip pain. The hip replacement procedure depends on the implant, which might not always be suitable because of problems with biocompatibility and mechanics, which could make the discomfort worse. In an effort to overcome these restrictions, scientists are looking into using scaffolds as an alternative implant method. Since three-dimensional (3D) printing can bio-imitate the complex patterns present in nature, it holds great promise as an effective fabrication method for customized organs. The paper covers the various manufacturing techniques, including direct 3D printing, and the determining variables for hip replacement. For hip replacement, stereo lithography (SLA), selective laser sintering (SLS), and fused deposition modeling (FDM) are employed. The article gives an overview of 3D tissue regeneration and discusses surface alterations of 3D printed implants. The traditional metallic and ceramic materials are discussed in order to understand the present standard hip replacement procedures and to emphasize their justification as the preferred material. Conclusions are then made after discussing the difficulties, moral issues, and current developments in the 3D printing of implants. Here are also the views and challenges. Based on the information presented in this analysis, 3D printing appears to hold great promise for opening up new avenues for the development of sustainable hip replacements.

Keywords: 3D printing; biocompatibility; biomaterials; cell adhesion; hip replacement; tissue regeneration

1.INTRODUCTION

The use of 3D-printed hip bracing in orthopaedic rehabilitation: the future? Recent developments in additive manufacturing technology have completely changed the medical industry by presenting previously unheard-of possibilities for the creation of customised orthotic devices. The creation of custom-made hip braces that are 3D printed to improve patient comfort, support, and mobility is one amazing use of this state-of-the-art technology. The one-size-fits-all nature of traditional hip braces frequently reduces their usefulness and comfort. But with 3D printing, the options are virtually limitless. A patient's hip can be digitally mapped using accurate scanning and modelling techniques, enabling the construction of a brace that precisely fits their individual anatomy. This customised method maximises support and stability while encouraging natural mobility, guaranteeing a snug and comfortable fit. Beyond personalisation, 3D printing has several benefits. The technique makes it possible to create robust but lightweight structures, which lessen the strain on patients and permit continuous mobility. Utilising sophisticated geometry and cutting-edge materials, 3D-printed .Hip braces help patients restore their range of motion by striking a careful balance between offering the support they need and allowing them complete range of motion. freedom and agility. Furthermore, the rehabilitation process itself can be made more personalised with the use of 3D printing. Because every patient has a different condition and set of goals, 3D-printed hip braces can be made to complement customised rehabilitation programmes and address particular problems. These braces can adjust to the patient's needs, improving treatment outcomes and speeding recovery, whether the patient is recuperating from hip injuries, managing chronic illnesses, or getting ready for surgery.In addition to offering unmatched personalisation and customisation, 3D printing may also result in more affordable options. It can be costly and time-consuming to manufacture orthotic devices using traditional procedures, especially when making unique designs. But 3D printing simplifies the manufacturing process and makes accurate and efficient manufacture possible, which could lower costs and make these sophisticated hip braces more widely available.As orthopaedics develops further, 3D-printed hip braces offer an amazing example of how technology and medicine may coexist. They provide a window into a future in which personalised orthotic devices maximize comfort, support, and mobility. These braces have the potential to revolutionise hip rehabilitation with continued breakthroughs in 3D printing technology, enabling patients on their path to better health and a higher standard of living. The largest ball and socket synovial joint in the body is this one. The femur head, or rounded edge of the femur, is this ball, and the socket, or acetabulum, is a curved dip around the lower area of the pelvis. The hip is shaped by the femur headsets located in the pelvic. The hip common can afflict anyone of any age, although it is most prevalent in the elderly. According to statistics, 76 million Americans, or a sizable portion of the population, suffer from pain of some kind. Although the precise causes of these aches are difficult to determine, the kind and location of the pain provide some indications. The majority of hip problems are related to issues originating in the lower back or buttocks. However, because other hip innervation occurs when the nerve is stimulated, the hip issues are related to the source of the pain in the groyne, thigh, and occasionally the knee. Furthermore, the National Joint Registry (NJR) for all types of hip procedures in England, Wales, Northern Ireland, and the Isle of Man has been overseen by the National Health Services (NHS) in the United Kingdom. According to the NJR analysis from 2016, there were around 101,651 replacements performed in a single year, representing a 3.5% rise from the year before. Hip pain can be caused by a number of illnesses, including arthritis, trauma, pinched wounds, cancer, and other issues related to lifestyle.

2. LITERATURE SURVEY

2.1. Biomechanical Analysis of Hip Braces after Hip Arthroscopic Surgery for Femroacetabular Impingement Syndrome: An Observational Study Kai Hirata, Yoichi Murata, Akihisa Hatakeyama, Makoto Takahashi, Patrick M. Quinn and Sushi Uchida. Hip braces can lessen the greater trochanter's acceleration and stop an excessive hip flexion angle. Individuals having arthroscopic repair of FAI One would benefit from using a hip brace after surgery.

2.2.3D printed zirconia ceramic hip joint with precise structure and broad- spectrum antibacterial properties: Yang long Zhu, Kuna Liu, Jian Jian Deng, Jing Ye, Fanrong Ai, Huan Ouyang, Tianlong Wu, Jingly Jian. The perfect implant material with exact structure, wear resistance, and potent antibacterial properties may be swiftly customized using ceramic 3D printing technology in conjunction with antibacterial nano modification.

2.3. Application of 3D scanner to measure physical size and improvement of hip brace manufacturing technology in severe cerebral palsy patients. Jung-Min Kim, Ji-Woon Lim, Sun-Young Choi, Sung-Han Rhim, Jaewon Beom, Ju-Seok Ryu. According to the findings of this pilot study, children with hip subluxation can benefit from quick hip correction using a customized hip brace made with a 3D scanner. cerebral palsy. By lessening discomfort, the adoption of a tailored brace is also anticipated to increase patient compliance.

2.4Effects of a hip brace on biomechanics and pain in people with femoroacetabular impingement Authors Nicolas R a Newcomba, Tim V Wrigleya, Rana S Hinmana, Jessica Kaszac, Libby Spiersa, John O'Donnellb, Kim L Bennella. Hip bracing was found to significantly but slightly minimize hip impinging movements in a group of young individuals with ongoing functional amputation symptoms. These motions Limitations did not transfer into clinical advantages after a four-week period of daily brace use or soon thereafter. These findings cast doubt on the usefulness of hip bracing for treating patients whose symptoms of FAI are persistent and unresponsive to conventional therapy.

2.5Three-dimensional Printing in Orthopedic Surgery: Current Applications and Future Developments Wixted, Colleen M. BS; Peterson, Jonathan R. MD; Kadakia, Rishin J. MD; Adams, Samuel B. MD: Every significant business uses this fascinating technology, which is widely used in three dimensions. This quickly developing field has made practically infinite 3D constructions made from an expanding a range of substances, such as polymers, metals, and even living cells. The ability to modify shapes to an extreme degree, the complexity and intricacy of made goods, the removal of assembly procedures, and the decrease of waste and inventory are all advantages of 3D printing.

2.6 3D Printing for Hip Implant Applications: A Review Yang long Zhu, Kuna Liu, Jian Jian Deng, Jing Ye, Fanrong Ai, Huan Ouyang, Tianlong Wu, Jingly Jian: Scaffold 3D printing technology is an area of research that is expanding quickly. Any scaffold that is 3D printed aims to resemble the hip area as closely as possible. It includes the mechanical strength (load carrying and stress-shielding), appropriate pore size for nutrient transport, and ECM characteristics. Hip bio implants will become more sophisticated and efficient as a result of the development of novel materials, bioinks, and effective printing methods

2.7 of a Passive Orthosis for Reducing the Load Transfer in the Hip Joint: The purpose of this work was to develop an exoskeleton model for hip joint load transmission. In this way, a mathematical analysis of the model's dual behavior served as the foundation for its development. dependence on the relevant factors were examined. In addition, a 3D CAD model, a computational model, and a prototype exoskeleton were created. Studies using numbers demonstrated the model's sustainability for a 20% decrease in the force placed on the hip joint during the stance portion of the gait cycle.

2.8 3D-Printed Regenerative Magnesium Phosphate Implant Ensures Stability and Restoration of Hip DysplasiaNasim Golafshan, Koen Willemsen, Firoz Babu Kadumudi, Elke Vorndran, Alireza Dolatshahi-Pirouz, Harrie Weinans, Bart C. H. van der Wal, Jos Malda, Miguel Castilho: Using printed (sacrificial) supporting structures, a flexible biomaterial that induces bone was carefully used to build the patient-specific design. Additionally, the implant was sturdy and It can induce in vitro bone development, is cytocompatible, resilient enough to withstand physiological pressures, and has the capacity to resorb in vivo. This novel regenerative implant offers a fresh approach to treating hip dysplasia in patients, both canine and maybe human.

2.9 Automatic Annotation of Hip Anatomy in Fluoroscopy for Robust and Efficient 2D/3D Registration: Robert Grupp, MathiasUnberath, CongGao, RachelHegeman, Ryan Murphy, Clayton Alexander, YoshitoOtake, Benjamin McArthur, Mehran Armand, Russell Taylor: Any benefits from navigation are lessened by this manual initiation, which impedes the surgical workflow. We suggest a technique for completely automated registration using neural network-generated annotations. Neuronal

2.10 3D-Printed Personalized Scoliosis Brace: Networks are trained to recognize landmarks in fluoroscopy and segment anatomy simultaneously. An intraoperatively incompatible 2D/3D registration of the hip anatomy is used to get training data. Ground Projected 3D annotations are utilized to establish true 2D labels. Intraoperative registration eliminates the need for human intervention by combining an intensity-based approach with network-inferred annotations. Across 6 cadaveric specimens, 366 fluoroscopic pictures have ground truth labeling. Networks obtained mean dice coefficients of 0.86, 0.87, 0.90, and 0.84 for left and right hemi elves and femurs in a leave-one-subject-out experiment. 5.0 mm was the average 2D landmark error.

3.HARDWARE DESCRIPTION

3.1PLA MATERIAL

PLA is made from sustainable resources like sugarcane or maize starch. Lactic acid is created by fermenting plant sugars, and after that acid is polymerized, PLA is created. Poly Lactic acid, or PLA for short, is a thermoplastic polymer that is derived from biomass and degrades naturally. The biodegradability of PLA is one of its main benefits. Under the correct environmental circumstances, PLA may be broken down by microorganisms in the environment, making it a more environmentally friendly plastic than typical petroleum-based ones. Because of its adaptability, low melting temperature, and convenience of usage, PLA is frequently utilized as a filament in 3D printing. It comes in a range of hues and compositions, some of which include other ingredients like metallic or wood fibers. PLA is utilized in many different applications, such as medical implants, packaging materials, 3D printing, and disposable tableware. Its application is especially prevalent in sectors and uses where the significance of a material's regenerative nature and biodegradability

4. SOFTWARE DESCRIPTION

THE SOFTWARE WE USED HERE:

- Sketch up software
- Mesh mixer
- Slicing software
- Thingiverse

4.1 SKETCH UP SOFTWARE:

Sketch Up is a multipurpose 3D modeling program for design and visualization. It is well-liked and easy to use by hobbyists, interior designers, and architects. You can make 3D models of landscapes, buildings, interiors, and more with Sketch Up. It provides a straightforward drawing interface with fundamental tools for surfaces, lines, and forms. Models can also be imported and exported in a variety of formats. Sketch Up is available to a variety of users with both free and paid editions.

4.2 MESH MIXER:

Autodesk created the potent 3D modeling program Mesh Mixer. It is renowned for having an easy-to-use interface and powerful editing and working with 3D meshes. Because it allows users to sculpt, texture, polish, and analyze 3D models, it is widely used by designers, enthusiasts, and professionals in industries such as game development, animation, and 3D printing. A mesh mixer can be used to combine different meshes, fix models, provide supports for 3D printing, and much more.

4.3 SOFTWARE SLICING

An important part of 3D printing is slicing software. It transforms a 3D model—usually in the OBJ or STL format—into a collection of G-code is a set of instructions that a 3D printer can read. This G-code sets print speed, temperature, and other print settings in addition to directing the printer's movements. Users of slicing program can import 3D models in OBJ and STL file formats, among others. These models can be acquired from internet sources or made with 3D design tools. The 3D model is divided into layers using slicing software, which also specifies how each layer will be printed. The layer height, which influences the print resolution, is frequently selectable by the user.

4.4 THINGIVERSE:

The website Thingiverse is devoted to the community sharing of digital design files made by users. mainly offering open-source, free hardware designs Contributors can choose a user license type for the designs they post on the site, which is licensed under the Creative Commons or GNU General Public Licenses. The files published by users on Thingiverse can be physically created using a variety of technologies, including 3D printers, laser cutters, milling machines, and many more. Thingiverse is widely utilized by 3D printer and Maker Bot operators, the RepRap Project, and DIY tech and Maker groups.

5. METHODOLOGY

1. Establish the Goal: Determine the precise ailment or medical condition that the hip brace is intended to treat.

2. Compile the Needs: Enumerate the functional and design specifications, including such as adjustability, size, comfort, and degree of support.

3. Investigate PLA Material: Find out about PLA's advantages and disadvantages as a material for medical device 3D printing.

4. 3D Model Design: Using the relevant design program, create a 3D model of the hip brace.

5. Test and Iterate: After printing a prototype in 3D, check that it fits and works as intended. Make the required changes to the design.

6. Certification and Compliance: Verify that the hip brace complies with all applicable safety requirements and medical device laws.

7. Manufacturing: Use 3D printing technology to start mass manufacturing as soon as the design is approved and finalized.

8. Post-Production: Check each brace, put the final touches on, and Put them in a package to give out.

9. Distribution and Monitoring: Create a distribution strategy and keep an eye on customer feedback so that the product may be improved as needed.

6. DESIGN AND IMPLEMENTATION

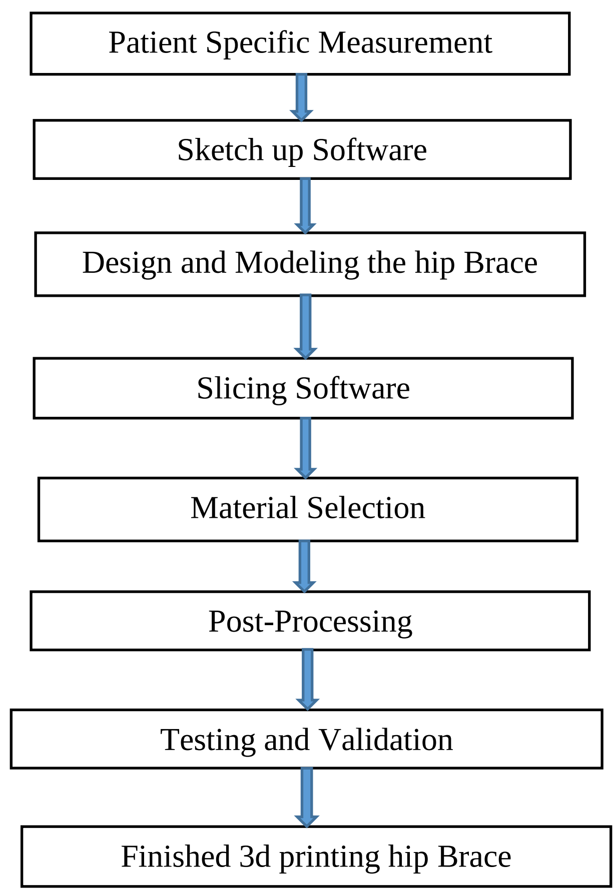
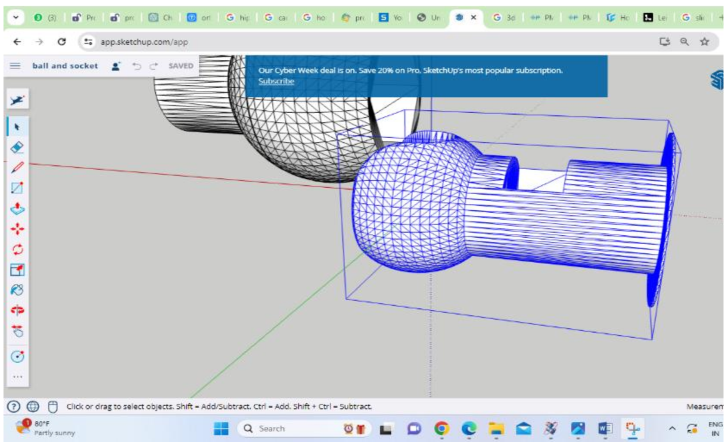


Fig 1 BLOCK DIAGRAM

7. RESULT

The outcomes of numerical and experimental models: crucial patient data, such as the person's name, age, gender, and any other pertinent medical data that could have impact the hip brace's design.

Patient Demographics	Measures
Name	Shamili. M
Hip Measurement	36^2=72cm
Right Leg Measurement	20cm
Thigh	22cm



8. CONCLUSION

3D-printed hip braces offer a specialized and tailored solution, which is a novel approach to orthopedic therapy. Making use of the these braces offer a customized fit and functionality thanks to the advantages of 3D printing technology. 3D hip braces are a potential option for improved orthopedic support because of its lightweight construction and capacity to cater to particular patient needs. However, it is advised to contact contemporary scientific literature, medical practitioners, or manufacturers with expertise in this sector for the most up-to-date and accurate information on outcomes and improvements.

REFERENCE

1.Do, A.V.; Khorsand, B.; Geary, S.M.; Salem, A.K. 3D printing of scaffolds for tissue regeneration applications. Adv. Healthc. Mater. 2015, 4, 1742–1762.

2. The Editors of Encyclopaedia Britannica. Pelvis, Encyclopædia Britannica. Encyclopædia Britannica, Inc. Available online: https://www.britannica.com/science/pelvis (accessed on 11 November 2020).

3. Rodriguez, D. The Basics of Hip Pain, Everyday Health. 2009. Available online: https://www.everydayhealth.com/pain-management/Hippain/understanding/index.aspx (accessed on 11 November 2020).

4. Committee, N.S. National Joint Registry for England and Wales: 14th Annual Report; Northern Ireland and the Isle of Man (NJR): Hemel Hempstead, UK, 2018. 5. Jain, A.; Clamp, K. Adult Hip Pain. InnovAiT 2019, 13, 21–27.

6. Older, J. Charnley low-friction arthroplasty: A worldwide retrospective review at 15 to 20 years. J. Arthroplast. 2002, 17, 675–680

7. Furnes, O.; Lie, S.A.; Espehaug, B.; Vollset, S.E.; Engesaeter, L.B.; Havelin, L.I. Hip disease and the prognosis of total Hip replacements: A review of 53,698 primary total Hip replacements reported to the Norwegian arthroplasty register 1987–1999. J. Bone Joint Surg. Br. Vol. 2001, 83, 579

8. Hughes, A.J.; DeBuitleir, C.; Soden, P.; O'Donnchadha, B.; Tansey, A.; Abdulkarim, A.; McMahon, C.; Hurson, C.J. 3D printing aids acetabular reconstruction in complex revision Hip arthroplasty. Adv. Orthop. 2017, 8925050 [

9. Gabriel, L.; Casey, J.; Gee, M.; Palmer, C.; Sinha, J.; Moxham, J.; Colegate-Stone, T.J. Value-based healthcare analysis of joint replacement surgery for patients with primary Hip osteoarthritis. BMJ Open Qual. 2019, 8, e000549

10. Hart, A.J.; Hart, A.; Panagiotopoulou, V.; Henckel, J. Personalised orthopedics–using 3D printing for tailor-made technical teaching, preoperative planning and precise placement of implants. Orthop Prod. News 2017, 178, 22–26.