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REVIEWS

Impact of mechanical engineering innovations in biomedical advancements

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Abstract
The principal objective of the present paper is to meticulously review the family of biomaterials used in implants. A spectrum of applications of biomaterials in the perspective of prosthesis is also presented. This paper also emphasises on the review of the recent advancements in the field of biomedical implants with respect to mechanical engineering perspective. The latest technologies such as finite element modelling of prosthetic implants, additive manufacturing of implants and certain experimental methods adopted in the field of prosthesis are discussed. Moreover, various models were modelled using SOLIDWORKS® 2022 modelling software and analysed using ANSYS® 2021 R2 finite element analysing software and implant models were additive manufactured to make this review more interesting and for better understanding. Overall, the latest technology in the field of mechanical engineering that fuels its impact in life-saving biomedical engineering has been discussed briefly.

Keywords Biomaterial · Prosthesis · Implants · Finite element method · Additive manufacturing · Biomedical devices

Introduction

A prosthesis or prosthetic implant is a manmade medical device that replaces a missing body part, which might be lost through injury, malady, or a condition present during childbirth. Prostheses are meant to re-establish the specific functions of the missing body part. The world of innovation [1] has led to the development of smart prosthetic implants with enhanced aesthetic and functional fronts. The utilisation of prosthesis has become significantly important recently, driven by increasing aging population.

In the present medical research, different configurations of implants have been studied and implemented for various applications in the human body. The main objective of these implants (knee implant, hip implant, dental implant, bone plate, pacemaker, etc.) is focused towards the protection of human lives [2]. These applications differ in terms of their placement and positions subject to the biocompatibility of the human body. These implants are put in areas of high mechanical pressure, for example in the joints during bone replacement or in areas of high synthetic and electrical movement, for example the use of neuroprosthetics [3]. Normally, the implants join the fractured bone as well as deliver good strength to the human body as a principal load-bearing member. Prostheses are broadly classified into external and internal prosthesis; the former deals with the artificial limbs and is employed externally; the latter deals with internal body implants (Fig. 1).

The perfect prosthesis should possess the characteristic features, viz. biocompatible to the human biological environment, corrosion resistance and wear resistance, acceptable solidarity to continue fatigue loading encountered by the joint and low moduli to limit bone resorption [4]. Modern composite materials like carbon fibre are making prosthetics both lighter and more grounded. Modern mechanical engineering tools play a vital role in the field of prosthesis. The modern tools include finite element analysis of implants, modern fabrication processes like additive manufacturing and experimentation techniques. Progressions in additive manufacturing and biometrics have upgraded the lives of amputees. In the field of biomechanics, mechanical testing is

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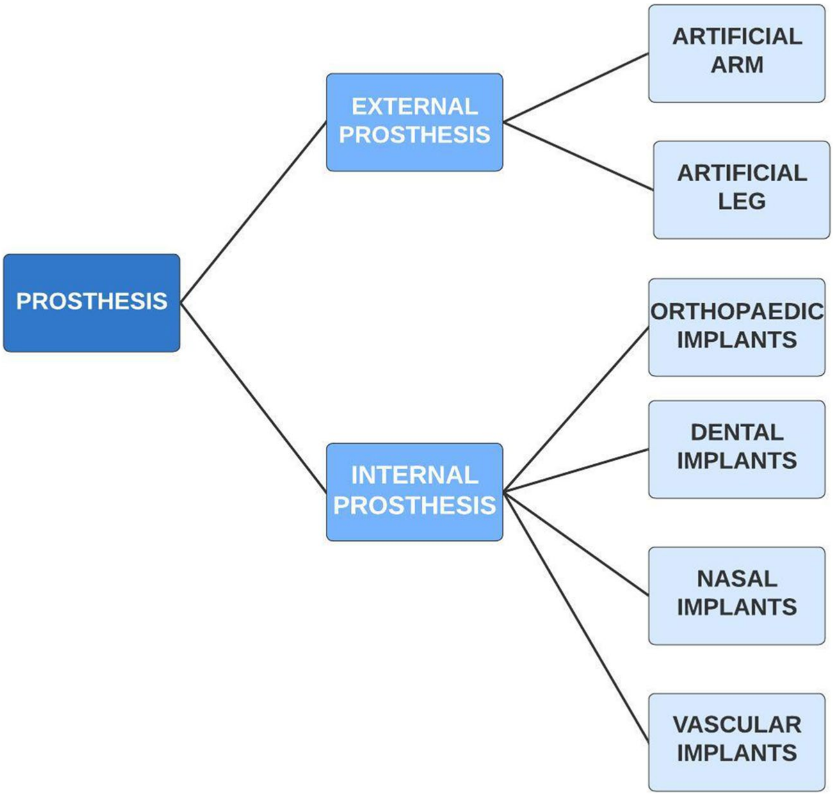
Fig. 1 Types of prosthesis



a very helpful tool. Mechanical testing is used in traditional biomechanics for a variety of purposes. For example, testing may be used to identify the mechanical characteristics of bone under various loading modes and diverse circumstances, such as age and disease status [5, 6]. Testing can also be used to evaluate fracture fixation methods and support clinical techniques. Implants and biomaterials can be tested mechanically to verify their strength and suitability for therapeutic applications. There are several fundamentals that must be understood in order to do mechanical testing correctly, even though the information from a mechanical test will vary [7–9].

The nexus of biomedical innovations and mechanical engineering has grown more and more significant in recent years, providing a bright future for implants. A breakthrough method in mechanical engineering called additive manufacturing (AM) is essential to creating complex, tailored structures that meet the particular requirements of biomedical applications. In order to help with design optimisation, finite element analysis (FEA) offers a potent tool for simulating the intricate mechanical behaviour of implants and biomaterials. In addition to these simulations, experimental techniques offer useful empirical data that helps to validate and improve the models. The combination of mechanical engineering perspectives and biomedical engineering knowledge not only improves the accuracy and productivity of implant development, but it also creates new opportunities for innovation and the application of state-of-the-art technologies in healthcare. The potential for ground-breaking discoveries and game-changing solutions in the field of implants is becoming more and more apparent as these two disciplines come together. This review deals with an introduction to different biomaterials used for fabrication of internal prosthesis and their recent advancement technologies in the field of mechanical engineering (Fig. 2).

Biomaterials

Biomaterials are engineering materials which are compatible to the human body. Every biomaterial is triggered to execute the assigned specific function for versatile applications [10]. Additionally, biomaterials possess the properties, viz. nontoxic, biocompatible, biotough, and ease in manufacturing. Biomaterials are either naturally available or synthesised in the research facility using metallic parts, polymers, ceramics or composite materials. Biomaterials are regularly utilised or potentially adjusted for clinical applications and in this way include part of a human body or biomedical devices which performs, increases, or replaces a characteristic capacity [11]. The family of biomaterials is indicated in Fig. 3.

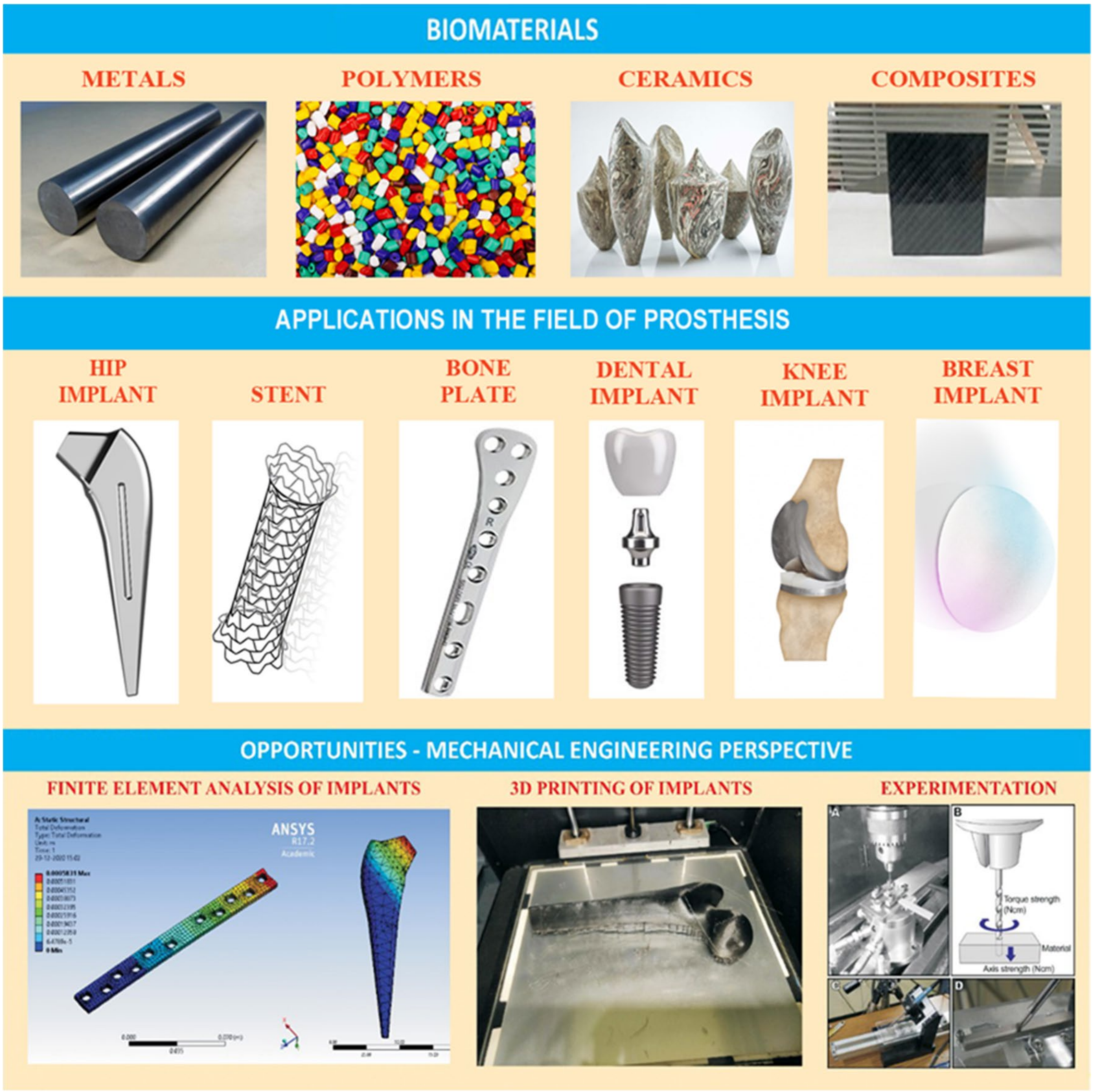


Fig. 2 Schematic representation of the work

Metals and alloys

Metallic biomaterials are mainly used in situations where maximum amount of load-bearing acts. Metallic biomaterials can be widely used in the field of prosthesis as they possess very good mechanical properties. But their biocompatibility is low; corrosion is possible in the physiological environment and mechanical properties differ from human tissues [12]. Stainless steel, cobalt-chromium alloys and titanium alloys are the metals and alloys mostly used in the field of prosthesis [13–15]. In joint prosthesis, metallic implants are used in the knee, hip and shoulder. Metals are mainly used hip replacement as they are capable of bearing load [16, 17]. A hip implant assembled model of acetabular component, plastic liner, femoral head and femoral stem has been attempted in the present paper using SOLIDWORKS® 3D modelling software version 2022 (Fig. 4a).

In knee replacement, metallic implants replace the load-bearing surfaces of the knee joint to cure the pain and disability [18, 19]. A knee implant assembly model of femoral component, plastic spacer and tibia component has been undertaken in the present paper using SOLIDWORKS® 2022 3D modelling software (Fig. 4b). In fracture fixation plates, metallic bone plates are used to heal the fractured bone [20, 21].

A distal femur locking bone plate model has been endeavoured in the present paper using SOLIDWORKS® 2022 3D modelling software (Fig. 4c). In dental implants, metals are used as tooth replacement [22, 23]. In heart valves, implants

Fig. 3 Types of biomaterials

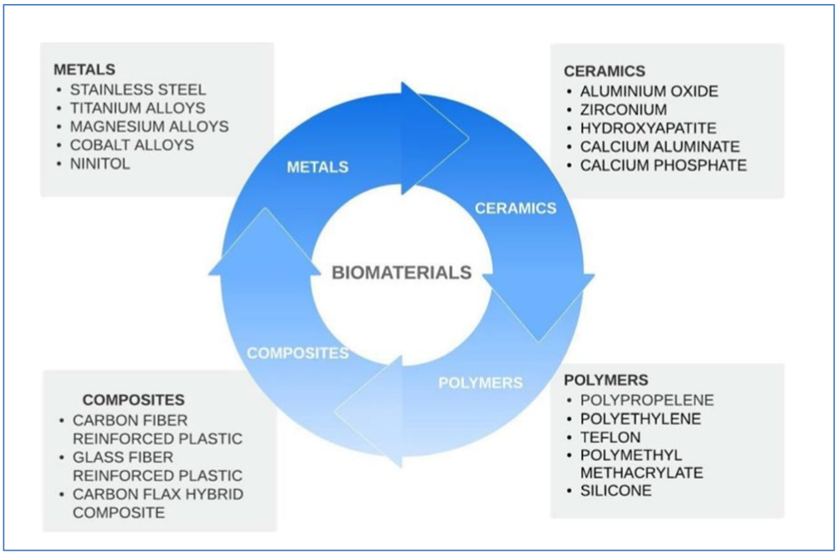
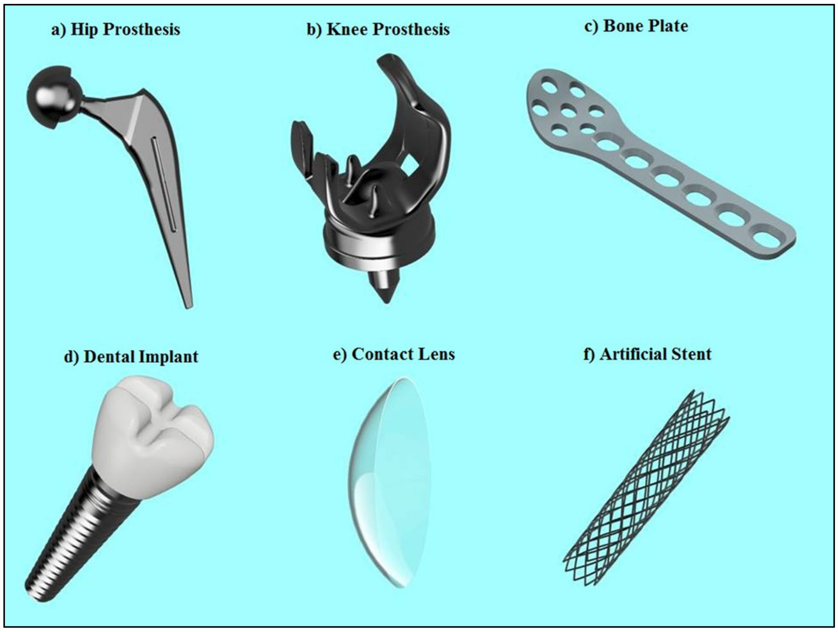


Fig. 4 Implants modelled using SOLIDWORKS modelling software



are used to replace damaged heart valves. Metallic implants are used in caged disc and hinged leaflet valves [24].

Ceramics

Ceramic biomaterials are highly biocompatible, corrosion resistant, good compression resistant and low to thermal conductivity. Ceramics show numerous applications as biomaterials due to their physicochemical properties. They have the advantage of being inert in the human body, and their hardness and resistance to abrasion make them useful for bones and tooth replacement. But ceramic composites possess low impact resistance and have difficulties in manufacturing and fabrication. Aluminium oxides, zirconia, calcium aluminates and calcium phosphates are the good candidate materials for ceramic materials in prosthesis [25, 26]. Zirconia is used in dental implants. It is bioinert, which means that it will never trigger chemical reactions, migrate to other sites in the body or corrode. However, if properly cared for, they are expected to last for 15–20 years or more, similar to titanium implants [27, 28]. A dental implant assembled model of crown, abutment and screw has been explored in the present paper using SOLIDWORKS® 20223D modelling software (Fig. 4d).

As ceramics can lessen wear and corrosion, they are employed as a covering material for other implants.

Orthopaedic and dental implants are increasingly being coated with ceramic materials to increase their wear resistance and promote tissue integration, which will increase the implant's stability over time. Ceramics are used as bone grafts to replace a missing bone by trauma. Ceramic-based bone grafts are synthetic products that have been widely utilised to reduce the need for iliac crest bone grafting. Ceramic matrices are inorganic, ionically bonded preparations that comprise a large collection of bone graft substitutes [29, 30]. Ceramics are also used as endoprobe for endoscopy treatments to examine a person's digestive tract without surgery [31, 32]. Ceramics are used as otologic implants to treat injuries related to ear. It is a surgically implanted electronic device that is placed in the temporal bone, which is located behind the ear. This is connected to an electrode array that has been inserted into the cochlea (inner ear) [33, 34]. Ceramics are used in tissue engineering to replace the biological tissue. Bioceramics can be manufactured into a range of forms such as powder, coating, and bulk to serve various purposes in the repair or replacement of human tissue [35, 36].

Polymers

Polymeric biomaterials are easy to synthesise and possess low density. Application of polymers is unlimited when compared to metallic and ceramic polymers. Since they may be made to suit a variety of uses, polymers are frequently employed in the manufacturing of implants. They are simple to manufacture and customise [37]. Biodegradable polymers [38] start to degrade inside the body in certain time when their work is complete. Polypropylene, polyethylene, Teflon, polymethyl methacrylate, silicone, and nylon are the mostly used prosthetic polymers. Polymeric biomaterials are used for making contact lenses for the enhancement of vision. The contact lenses lie on the cornea and they are a replacement for eyeglasses [39, 40]. A contact lens model has been introduced in the present paper using SOLIDWORKS® 2022 3D modelling software (Fig. 4e).

Silicone is used in breast implants. These implants are used to change the size and shape of the breasts and also used to cure congenital defects and deformities of the chest wall. Most silicone and saline implants are FDA approved for 10–20 years, but this does not mean that you have to get them replaced every 10–20 years. You can safely go beyond these time frames, and most patients only have to have 1–2 replacements in their lifetime [41, 42]. Polymers are used in nasal implant which supports lateral cartilage in the nose. One implant may be used to correct one side, or two may be used to correct both sides of the nose to open the nasal passages. The material is gradually absorbed over a period of about 18 months. Supporting the cartilage reduces nasal airway obstruction [43, 44] and helps breathe better. Polymers are used as a coating material in cochlear implants that is used for improving the hearing [45]. Teflon is used for vascular implants, where they substitute an infected artery. Teflon has an excellent patency rate, is simple to apply, and has acceptable interactions with tissues. It also tolerates pressure and flows in medium and large arteries [46, 47]. An artificial stent model has been modelled in this paper using SOLIDWORKS® 2022 software (Fig. 4f).

Composite

Biomaterial using composites has a main advantage of flexibility in design, as their properties are direction dependant and can be optimised [48]. Composites possess greater specific strength, greater specific stiffness, and greater fatigue strength with lesser weight. Due to these advantages, composites replace other biomaterials in various prosthetic implants [49, 50]. In dental implants, composites are used in fixing the missing or damaged teeth. Different types of composite used since its introduction include macrofill composites, microfill composites, hybrid composites, and nanofill composites [51, 52]. Composites and hybrid composites are used in tissue engineering [53, 54]. The usages of composite materials in the orthopaedics field have been increased drastically in the recent years. Composites are used for joint prosthesis in hip, knee and shoulder replacement [55, 56]. Composites are used in bone plates for curing the fractured bone. Composites are also used for making artificial bones for scientific analysis. Due to their capacity to precisely mimic the properties of real bone when compared to first-generation and second-generation bone substitute materials, composites are currently regarded as third-generation orthopaedic biomaterials. Due to the higher stiffness and strength of the inorganic material's intrinsic qualities, the combination of polymers and ceramic phases results in composite materials with superior mechanical capabilities [57, 58]. Composites are used in artificial tendons which connect muscle to bone and are capable of holding the pressure. To mimic the compliance of a natural anterior cruciate tendon, an artificial ligament must meet stringent specifications and possess at least three crucial characteristics, such as high tensile strength, high elongation, and the suitable stiffness [59, 60].

Advancements in the field of implants: mechanical engineering perspective

Finite element simulation in implants

The finite element analysis (FEA) is the simulation of a system utilising the numerical procedure so called finite element method (FEM). The idea of breaking intricate items down into smaller ones or building complicated objects out of simpler ones is the foundation of the finite element approach, also known as finite element analysis. Mathematics frequently does not provide sufficiently strong techniques for discovering the exact answer, and frequently not even an approximate one, to a practical problem. So, the fundamental principle behind the finite element approach is to use discrete components or pieces whose behaviour is completely known in order to solve a complex problem. In order to calculate and analyse complicated resistance constructions with more specialised qualities, such as biomechanical ones, for which analytical calculation methods are no longer useful, the finite element analysis approach is also evidently necessary [61–63].

In the present paper, the finite element analysis of hip implant and femur bone has been carried out in ANSYS® 2021 R2 (Fig. 5). Both were first modelled using SOLIDWORKS® 2022. Then, this 3D model is imported into ANSYS® 2021 R2 environment and simulated. FEA has numerous applications in the field of implants; some are mentioned in Table 1 [64–72].

Additive manufacturing in implants

Additive manufacturing is an emerging area in the field of medical prosthesis which is a revolutionary manufacturing process that involves building three-dimensional objects layer by layer from digital models. Unlike traditional subtractive manufacturing methods that involve cutting or shaping materials to create the desired object, additive manufacturing adds material gradually to create the final product. The process typically begins with the creation of a digital model using computer-aided design (CAD) software. This digital model is then sliced into thin cross-sectional layers. During the printing process, these layers are successively deposited, solidified, or fused to build up the final three-dimensional object. Various materials can be used in additive manufacturing, including plastics, metals, ceramics, and even biological materials. Different technologies exist within the realm of additive manufacturing, each with its own set of advantages and applications. Common techniques include fused deposition modelling (FDM), stereolithography (SLA), selective laser sintering (SLS), and electron beam melting (EBM). Additive manufacturing offers several benefits, such as the ability to produce complex and customised geometries, reduce material waste, and facilitate rapid prototyping and on-demand production. It has found applications across various industries, including aerospace, healthcare, automotive, and consumer goods [73]. Additive manufacturing is engineered to create both internal and external prosthesis. Additive manufactured prosthetics offer an economically and genuinely necessary assistance for the amputees. Additive manufacturing is becoming a major technique for the manufacturing of implants. It is a developing technology that creates a real-world 3D item from a 3D digital model. In 2012, a hand prosthesis known as "Robohand"—the first upper limb prosthesis to be 3D printed—was created. Since then, more additive manufactured prosthetic devices have become accessible, and the technology has continued to advance but is still in its

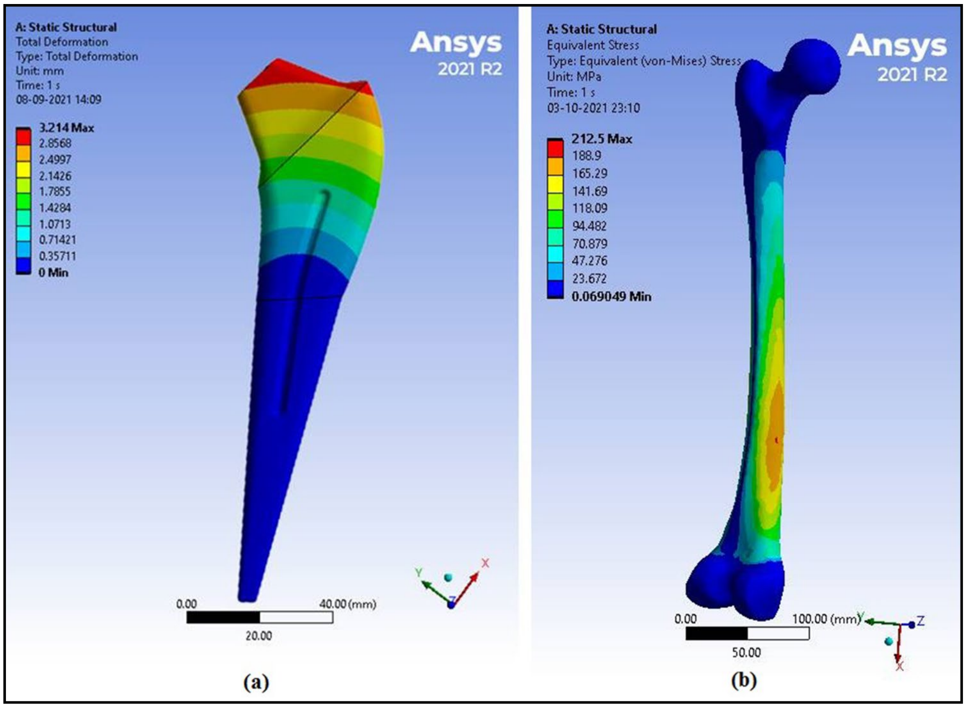


Fig. 5 Finite element analysis. **a** Hip implant stem. **b** Femur bone

Table 1 Application of finite element simulation in the field of prosthesis

Software used	Prosthetic implant analysed	Procedure followed	Results obtained	Ref
ABAQUS	Hip prosthesis	Material—titanium alloy Loading—fixed in the bottom, load in the top	Von Mises stress	[64]
ANSYS 11.0	Knee prosthesis	Material—polyethylene chopped carbon fibre Material—composite Loading—compressive load	Distribution of shear stress, von Mises stress	[65]
SOLIDWORKS	Shoulder prosthesis	Material—cobalt-chrome Loading—compressive and shear	Stress, displacement	[66]
ANSYS	Bone plate	Material—SS, titanium, alumina, polymethyl methacrylate, nylon Mesh—fine mesh Loading—fixed in the bottom, compression load from the top	Stress, directional deformation Inference—titanium is said to be the better material for bone plates based on results	[67]
ANSYS	Dental implant	Material—cobalt-chrome Loading—vertical load	Von Mises stress	[68]
ABAQUS 6.12	Breast implant	Material—silicone Loading—static and dynamic load	Stress	[69]
Inventor Professional 2017	Contact lenses	Material—polymethyl methacrylate, polycarbonate Loading—compressive	Von Mises stress, displacement	[70]
ANSYS	Maxillary implant	Material—acrylic Element type—isotropic and linearly elastic Loading—buckle load	Von Mises stress	[71]
ABAQUS	Vascular implant (stent)	Material—cobalt alloy Mesh—four node membrane element	Deformation	[72]

early stages in several areas. In fact, more advancement is needed to enhance the comfort, strength, and functionality of additive manufactured prosthetics as well as to increase their anthropomorphism and cosmesis. The most creative and printable prosthesis is the hands. Also, the majority of additive manufactured upper limb prosthetics are made for kids. Their growth, which necessitates a recurring change in prosthesis, is the primary cause of this trend. For many families, having to continually buy new commercial equipment is a burden. Hence, prosthesis serves as a temporary or permanent solution for this population. Furthermore, the abandonment rate can be reduced compared to traditional commercial prostheses since additive manufactured prostheses can be customised with patterns selected by the young receivers and some of the devices are lightweight and simple to activate [74–76]. Figure 6a is an additive manufactured hip implant stem, and Fig. 6b is a bone plate both additive manufactured using FDM technology. Table 2 [5, 77–84] explains the additive manufactured implants for biomedical applications Fig. 7 [85, 86].

Experimental methods for testing implants

Experimental validation plays a pivotal role in ensuring the accuracy, reliability, and real-world applicability of finite element analysis (FEA) simulations for implants. While FEA provides a powerful virtual platform to predict and analyse the mechanical behaviour of implants under various conditions, experimental validation serves as a crucial step in bridging the gap between simulation and reality. Experimental testing of prosthesis is a challenging task. Setup for testing the implants is crafted based upon the requirements.

When these orthopaedic implants are mechanically tested, the rigidity of the implant, the number of cycles it can withstand before breaking, how the implant affects the rest of the body around it, and a variety of other requirements may be examined. Regardless of the situation or requirement, it is crucial to understand that an implant's testing process should always aim to simulate how it would be mechanically loaded in the body during clinical use. The anatomy around the implant, the biomechanics of the implant, the body, and the interaction between the body and implant must all be considered during appropriate testing of orthopaedic implants. At every stage, one should be aware of the implant's design and its intended use in patients.

Testing implants involves a range of setups to evaluate their performance, durability, and safety. The specific setups can vary depending on the type of implant and the desired characteristics to be assessed. Mechanical testing rig is used in evaluating the mechanical strength, stability,

Fig. 6 Additive manufactured. **a** Hip implant stem. **b** Bone plate

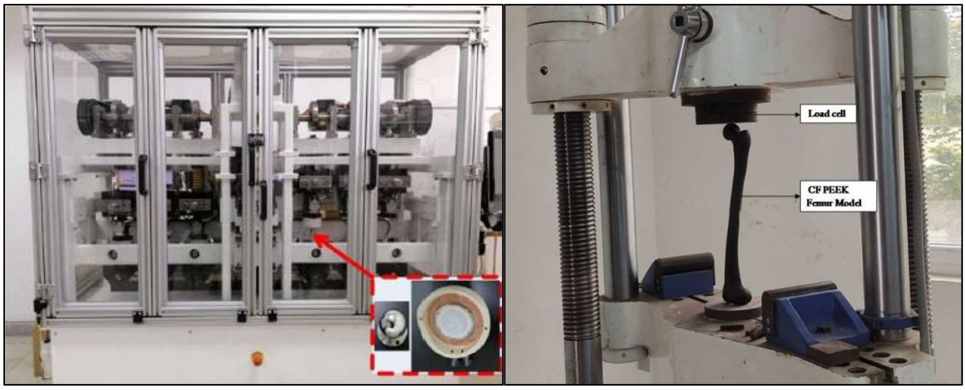


Fig. 7 Experimental testing [85]· **a** Hip prosthesis. **b** Femur model [86]

and fatigue resistance of the implant. Instron or similar testing machines are often used to apply controlled forces, torque, or cyclic loading to simulate the physiological conditions the implant may experience [5]. Wear and friction testing apparatus is used in examining the wear resistance and frictional properties of materials used in the implant. Tribometers or pin-on-disk setups simulate the relative motion between implant components to assess wear rates and friction coefficients [87, 88]. Electrochemical corrosion testing is used for evaluating the corrosion resistance of metallic implants in physiological environments. Electrochemical cells are used to subject the implant to corrosive conditions, measuring parameters like corrosion potential and corrosion current [89, 90]. In vitro and in vivo testing chambers are used for assessing biological responses to implants in controlled environments. Cells or tissues are cultured in vitro on the implant surface or implanted into animal models to study factors like tissue integration, host response, and long-term stability [91, 92]. Radiographic testing setup is used for examining the structural integrity and positioning of implants. X-ray or CT imaging is used to visualise the implant within the body,

Table 2 Application of additive manufacturing in the field of prosthesis

Prosthetic implant	Material	Technique	Key points	Ref
Hip prosthesis	Polylactic acid	Fused deposition modelling	Polylactic acid hip prosthesis for medical demonstration	[77]
Knee prosthesis	Polycarbonate	Fused deposition modelling	Wear and strength analysis was performed	[78]
Shoulder prosthesis	Polylactic acid	Fused deposition modelling	Additive manufacturing is useful for planning with accurate reproduction of transverse check anatomy	[79]
Bone plate	Polylactic acid	Extrusion bot filament extruder	Additive manufacturing of plates, screw was done and additionally plates were loaded for localised drug delivery	[80]
Prosthetic teeth	Methacrylate-based photo polymerised resin	Stereolithography technology	Prosthetic teeth were additive manufactured and chipping and indirect tensile fracture tests were conducted until fracture. The results suggested that the used resin material is good for prosthetic teeth	[81]
Contact lenses	Silicon and epoxy resin	Print optical technology	Lens made by this method of 3D printing can help optics designs at low cost	[82]
Nasal implant	Alkali soluble photopolymer	Projection-based micro stereo lithography	Nasal cartilage implant was manufactured and hydrogel containing human stem cells were injected into the implant	[83]
Vascular implant	Propylene fumarate	Digital stereo lithography	Additive manufacturing of a biodegradable polymeric vascular graft	[5]
Artificial tendon	Polycarbonate	Electro-hydrodynamic jet printing	This method of tendon manufacturing has the effectiveness to be an alternative tendon regeneration tool	[84]

allowing for assessment of its placement, alignment, and any potential issues [93, 94].

These setups collectively provide a comprehensive understanding of an implant's performance, ensuring that it meets safety and efficacy standards before being introduced for clinical use. The combination of in silico (computational), in vitro (laboratory), and in vivo (animal or human) testing allows for a thorough evaluation of implant behaviour in different contexts. Many of these experimental methods followed in testing the implants by the past researchers (Table 3) [85, 95–100].

Future directions and challenges

Exploration of the potential of 4D printing and advanced biofabrication techniques for creating dynamic and self-assembling implants [101]. Investigation on the integration of nanotechnology for developing nanocomposite biomaterials with enhanced mechanical properties and targeted drug delivery capabilities. The introduction of nanoscale materials can improve the performance and longevity of implants [102, 103]. Usage of patient-specific data, such as medical imaging and genetic information, to create custom-designed implants that fit patients' unique anatomical and biomechanical characteristics [104, 105]. The development of smart implants equipped with sensors and actuators that can monitor their own performance and respond to physiological changes [106, 107]. The advancement of biodegradable materials that can provide temporary mechanical support or drug delivery and then naturally degrade, reducing the need for additional surgeries for implant removal [108, 109]. Biomimetic design principles that mimic natural structures and mechanisms to create highly efficient and mechanically robust implants [110, 111]. The development of non-invasive or minimally invasive techniques for assessing implant performance in vivo, allowing for real-time monitoring and early detection of potential issues [112, 113].

The challenge of implants is ensuring the long-term durability and reliability of implants, especially in high-stress environments. Exploring the strategies for improving the mechanical stability of implants over their lifespan [114, 115]. Ongoing challenges related to biocompatibility, including the immune response to implants and potential allergic reactions. Investigating the novel surface modifications and coatings to enhance biocompatibility [116, 117]. Addressing regulatory challenges related to the approval and standardisation of new biomaterials and implant technologies [118, 119]. Examining balance between developing advanced biomaterials and implants and ensuring cost-effectiveness for widespread adoption. Exploring strategies to make cutting-edge technologies accessible and affordable [120, 121]. The challenges related to the integration of implants with the host tissue, such as minimising the risk of infection,

Table 3 Experimental methods in prosthesis

Prosthetic implant	Material	Experimental technique	Key points	Ref
Hip prosthesis	Polyether ether ketone and cobalt–chromium–molybdenum	Hip simulator	Cobalt–chromium–molybdenum taper sleeve inserted into the neck of the polyether ether ketone artificial hip prosthesis can significantly lower the micromotion of the head-neck interface	[85]
Knee prosthesis	Cobalt–chromium–molybdenum	Leeds ProSim pneumatic six station knee simulator	This experiment helps in understanding the wear properties of the implant and enhancing the wear property	[95]
Shoulder prosthesis	Polyurethane	Rocking-horse test	This experiment is done to glenoid loosening in shoulder prosthesis and improves its design	[96]
Bone plate	Carbon flax epoxy hybrid composite	Tensile, shear and flexural test	The experimentation overviews the material properties of carbon flax epoxy hybrid composite for bone plate fabrication	[97]
Bone plate	E-glass fabric reinforced epoxy composite	Three-point bend roller spans	A new bone plate model has been designed with the stiffness value nearer to that of the bone	[98]
Dental implant	Zirconia and PMMA	Laser subtractive process	The fabrication of dental prosthesis by this method improves the surface finish	[99]
Breast implant	Poly implant prosthesis	Scanning electron microscope analysis and fatigue test	This experiment helps in demonstrating the rupture behaviour of breast implants	[100]

promoting tissue regeneration, and preventing implant rejection [122]. Considering the ethical implications of implantable technologies, such as issues related to privacy, informed consent, and equitable access to advanced treatments [123, 124]. Examining the environmental impact of biomaterials, implant production, and implementing sustainable practices and materials to reduce the ecological footprint of the field [125, 126].

Conclusion

This review paper enumerates the internal prosthetic implant in the view of materials, applications, additive manufacturing, numerical and experimental modelling. The researches of biomaterials in synthesis of prosthesis are rapidly increasing day by day in the scope of optimising the best devices as it is being reinforced in the human body. On the other hand, composite material plays a vital role in prosthetic implants due to their excellent characteristic features. Finite element simulation gives the freedom of choosing the best lightweight materials, good mechanical behaviour and desired directional properties of the implants before being applied inside the human body. An attempt has been made in this paper for modelling hip implant, shoulder implant, bone plate, dental implant, contact lens, artificial stent models using SOLIDWORKS® 2022. A finite element model of a hip implant and femur bone is also explored in this paper using ANSYS® 2021 R2. 3D printing has been a remarkable technology in the prosthetic field as it has reduced the time and cost in the manufacturing implants. 3D printing of a hip implant stem has been fabricated in this paper. Different experimental setups are also being used for validating the performance of prosthesis. Various advancements are being made in the prosthetic field for the betterment of the properties of the biomaterials based on the desired applications. Thus, biomaterials are the future for the medical and engineering researchers for the design and development of optimal, sustainable, efficient and lightweight implants.

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Declarations

Conflict of interest The authors declare no competing interests.

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