Signed details of the excellence in research work for which the nomination is being sent

Category- Medical Sciences-Basic research

Being a veterinarian, I have unique interdisciplinary expertise as well as exposure to experimentation related to calcium phosphate-based scaffolds and cement, polymeric biomaterials, bioactive glasses as bone graft substitutes, drug delivery systems for treating osteomyelitis, bioactive coated implants in fracture healing, and dental implants for various animal models. The research work on biomedical implants has been started during my doctoral studies in collaboration with the CGCRI (a unit of CSIR) and continued thereafter with 14 nationally funded projects from the Indian Council of Agricultural Research, Department of Biotechnology (DBT), the Department of Science and Technology (DST), the Government of India. The research endeavors yielded a new trend of cost-effective, well-accepted, and effective technologies for the treatment of complicated orthopedic diseases of animals vis-à-vis curing human patients. The cross-cutting multidisciplinary research aptitude has already been established and proven through achieving the prestigious Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences, 2021; Tata Innovation Fellowship, Jawaharlal Nehru Award for Outstanding Post-Graduate Agricultural Research 2007, National Bioscience Award for career development 2008, Biotech Process, Product Development and Commercialization Award, CSIR Technology Award-2010- as a part of the award-winning team by national apex body like ICAR, DBT, CSIR, Government of India, respectively.

This apparent observation stimulates the scientific aptitude of myself to get some innovative findings following the in-depth study on the subject concerned in an experimental animal model and its subsequent application in human patients by the Doctors of R.G. Kar Medical College, Kolkata suffering from skeletal disorders and complicated bone diseases and reconstruction of congenital defects.

- Research on ceramic biomaterials in segmental bone healing, as well as local drug delivery systems in osteomyelitis in the animal model, provided sufficient knowledge in human orthopedic practices. Low-cost, effective technology of Cefuroxime axetil-loaded calcium phosphate and bioactive glass-based delivery system was developed to treat animal osteomyelitis which had also been clinically applied in human osteomyelitis patients**.**

- Research work on "Development of marine biomaterials alone or in combination with conventional and unconventional growth factors in bone tissue engineering" sponsored by the Department of Biotechnology, Government of India had been carried out using marine-based biomaterials like porous chitosan, sponge skeleton, and coral in animal bone healing and the results had developed a new technology of marine-based material in bone healing.

- Animal trial of different bioceramic coated intramedullary pinning for fracture healing possesses a significant role in many orthopedic clinical cases of animal subjects and is being used for veterinary and human orthopedic patients.

- Ceramic-coated metallic biomaterials, especially with bioactive glass-coated Ti-6Al-4V dental implants had been successfully worked out in animal models and showed a new vista in human dental surgery cases.

- Research work on "Development of Ceramic-based implantable delivery system for sustained release of the drugs for the treatment of Osteomyelitis in human patients "sponsored by DST,

Government of India in collaboration with: Central Glass and Ceramic Research Institute and R. G. Kar Medical College and Hospital, Kolkata had been completed and the outcome is now routinely practiced in human osteomyelitis patients.

- Isolation of "Osteogenic inhibitor(s) from marine mollusk *Terebra dislocate*" and "Novel immunostimulator/ immunomodulator from Marine Mollusc *Telescopium telescopium* had been carried out successfully and filed **two Indian Patent** vide No 1170/KOL/2009 and 1399/Kol/2010 dated 13.12.2010 respectively. This work opened a new path of biotechnological intervention of low-cost material for the enhancement of immunity in animals.

- Evaluation of autologous bone marrow grafting alone and in combination with human placental extract as wound, healing potentialities had been carried out in animal models which shows sufficient possibilities in the management of complicated wound healing in both animals and humans.

- A detailed study involving Magnesium, Titanium, and Zinc (2% and 5%) substituted hydroxyapatite has been carried out in an animal model to understand the influence of these dopants on the physical, mechanical, and *in-vivo* biological properties of the bioactive hydroxyapatite ceramics for orthopedic reconstructive procedures. The results are very promising for utilization in orthopedic surgical cases. This study of using metallic ion dopants may reduce the use of high-cost bone-derived growth factors in animal and human orthopaedic surgery.

- DST, Government of India funded sponsored projects on the "Development of bioactive ceramic coating on orthopedic implants (metallic) for sustained, localized delivery of bisphosphonates to improve fixation" had been completed with encouraging results of ceramic coated orthopedic implants for local and sustained delivery of bisphosphonates to improve fixation.

- Collaboration work with the School of Mechanical and Materials Engineering, Department of Chemistry, School of Mechanical and Materials Engineering, Washington State University, the USA as an Adjunct Professor on 3D printed metallic ion doped Calcium phosphate-based bone graft materials both scaffold and cement alone and in combination with dopants and silver nanoparticle doped metallic implants for osteomyelitis treatment had been carried out to stimulate the growth of new bone at a faster rate leading to rapid healing than other available methods in an animal model. The outcome of this experimentation explored a new horizon in clinical cases of orthopedic surgery for their effective potentiality of treating bone loss in a variety of orthopedic disorders in human and veterinary subjects**.**

- Prof. Nandi has developed low-cost, safe, biocompatible animal cartilage for surgical implantation in a human patient from a DBT-sponsored project on "*Development of Animal cartilage for surgical implantation in Microtia and Rhinoplasty of human patient*". The developed decellularized animal cartilage had been applied in human rhinoplasty and microtia patients with effective outcomes. The research work has tremendous outcomes in human plastic and reconstructive surgery with a very low-cost material and has societal

benefits. The work had been completed and finally accepted for recommendation by the Department of Biotechnology, Government of India.

- To find an alternative dressing material for faster healing, scientists from the Indian Institute of Technology (IIT), Guwahati, and West Bengal University of Animal and Fishery Sciences, Kolkata prepared the nanofibrous mats by blending silk protein fibroin with a polymer. The mats were then loaded with epidermal growth factor and coated with antibiotic ciprofloxacin. He had carried out the said work in an animal model in a DBT's Twin program on North East entitled "*Development of novel tissue engineered silk biomaterial based wound dressing patch for diabetic foot ulcers*". The work has tremendous promise in plastic surgery and curing complicated diabetic wounds in animal and human patients in the coming future.

- Prof. Nandi has also carried out research work on lithium and strontium-doped bioactive glass in animal orthopedic models with notable outcomes. The outcome of research work may reduce the use of costly growth factors in bone regeneration in the clinical context of human and animal orthopedic surgery.

- Prof. Nandi also worked with resorbable magnesium based both coated and uncoated and E-glass-based bone plates in an animal model. The work has tremendous potential in human orthopedic and maxillofacial surgery where one application may serve the purpose and may avoid the second surgery for its removal. In the Indian context, this work may be of first of its kind and discussion is underway regarding the technology transfer of this product to the Indian industry for large-scale commercial application in clinical patients.

- Prof. Nandi completed a project work entitled "*Multilayered customized skin graft for full thickness wound*" in collaboration with the School of Medical Science and Technology, Indian Institute of Technology, Kharagpur funded by DBT, Government of India. The work has a tremendous promise in complicated wound healing in animal vis-à-vis humans, especially in burn patients.

- Prof. Nandi had also worked with gelatin-chitosan- bioactive glass scaffold, silk-reinforced doped bone cement in bone regeneration, and silk-based small-diameter vascular graft in an animal model which has tremendous promise in human application. The work has some exemplary and interesting results to which future research can be carried on. It has made a tremendous landmark in the research progress of the application of bone substitute material to human health.

- Prof. Nandi had also worked with non-mulberry silk protein fibroin blended and grafted poly (Є-caprolactone) nanofibrous matrices, Nitinol implant alone and in combination with growth factor for *in vivo* bone regeneration, carbon nanotube reinforced hydroxyapatite in bone regeneration and silk-based scaffold in cartilage regeneration. The work has tremendous promise in the utilization of biomaterial in bone and cartilage tissue engineering.

- Work performed on carbon nanofiber-reinforced non-mulberry silk fibroin scaffolds for load-bearing tissue regeneration in the animal model had tremendous promise in bone tissue engineering.

- Research work has been carried out on *in vivo* performance analysis of bioceramics and chitosan-coated stainless-steel implants in the animal model for better fracture fixation and one research paper is under active consideration in Elsevier Journal.

- An in-depth material characterization and *in vivo,* animal trial has been carried out testing the hypothesis that silver-coated stainless-steel pins can effectively control infection rate in treating osteomyelitis and improve mechanical integrity at the pin bone interface when compared to uncoated pins.

- Research work was carried out on the evaluation of mesoporous bioactive glass alone and in combination with growth factors in bone healing in the animal model. The work shows a new vista in the arena of bone tissue engineering.

- Research work was carried out to assess the influence of external vibration on a doped tricalcium phosphate scaffold in an animal model of bone healing. Initial results are very encouraging.

- Research work has also been carried out including developing methods for evaluation of small diameter vascular conduits using mulberry and non-mulberry patterned silk films, a potential matrix from native honeybee silk membrane for tissue engineering and regenerative medicine, nitrogenous bisphosphonate incorporated vitreous coating (with/without polymer) on surgical grade SS316L implant material to improve fixation at the damaged tissue site in the animal model.

- Research work was carried out in collaboration with the Indian Institute of Technology, Guwahati on developing bioactive blend silk matrices towards generating bioartificial liver constructs, bioartificial pancreas for sustained insulin production in diabetic patients, stacked silk-cell monolayers as a biomimetic three-dimensional construct for cardiac tissue reconstruction.

- Research work was carried out on metallic ion-doped magnesium silicate implants in bone healing under his guidance and one doctorate student worked on metallic ion-doped magnesium phosphate implants in bone regeneration. Both works have tremendous promise in biomaterial science vis-à-vis in bone regeneration in animals as well as in human subjects.

- Research work was carried out on the development of biodegradable iron and Magnesium based alloy material and resin-based polymeric systems in bone regeneration in the animal model.

- In collaboration with the Indian Institute of Science, Education, and Research, research work was carried out to assess the efficacy of a peptide-based sealant and **one Indian patent** had been submitted. He is also working with peptide-based material in suture-free wound closure and cancer therapy in the animal model.

- Research work was carried out to test the effects of immunomodulatory injectable silk hydrogels maintaining functional islets and promoting anti-inflammatory M2 macrophage polarization in collaboration with IIT, Guwahati.

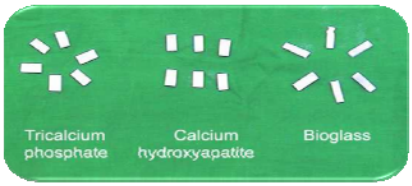
- Research work was carried out on an acellular caprine choncal cartilage matrix for cartilage tissue engineering applications.

- Research work was carried out on fish collagen with doped bioactive glass electrospun nanofibers in diabetic wound healing application in animal models from a highly prestigious Tata Innovation Fellowship cum project of the Department of Biotechnology, Government of India.

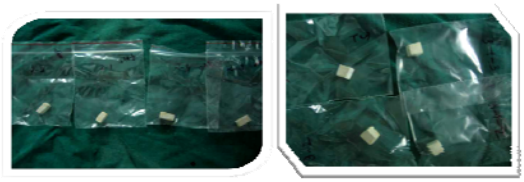
- Research work was carried out on the development of porous iron and magnesium-based alloy, resin-based biodegradable osteosynthesis systems, PRF-loaded doped magnesium phosphate material in bone regeneration as well as nano zinc and silver-based material in wound healing.

My work is basically on application-oriented innovations in the animal model and could serve/serve the purpose of treatment of complicated cartilage, orthopedic, and soft tissue problems in animal and human patients.

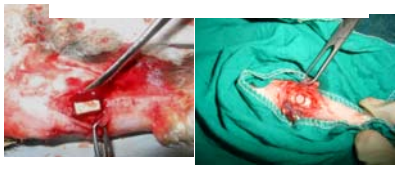
Osteomyelitis bone

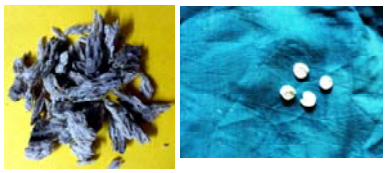


Porous ceramic and glass-based biomaterial

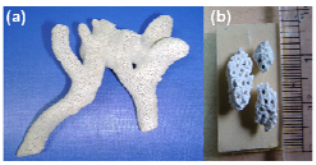


Antibiotic loaded Calcium hydroxyapatite beads

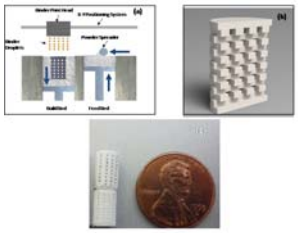


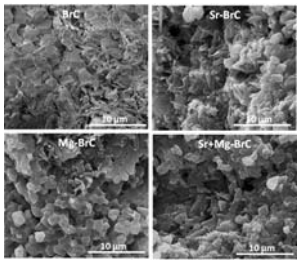


Converted Marine sponge as bone graft material

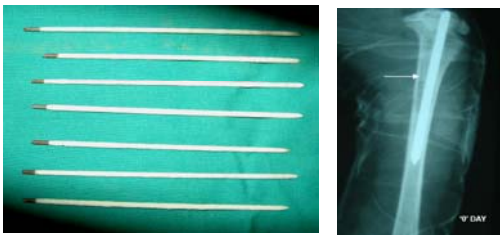


Converted Marine Coral as bone graft material





Si and Zn doped 3D printed β-TCP scaffolds as bone graft material

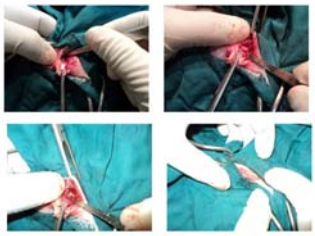


Bioceramic coated stainless steel pin in animal model

Li and Si doped Bioactive glass in animal model

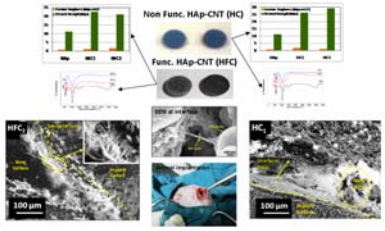
Curing of osteomyelitis in human

The biodegradable coated bone plate for orthopaedic use

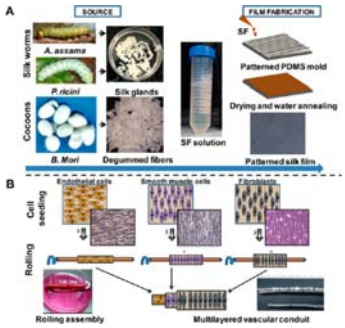


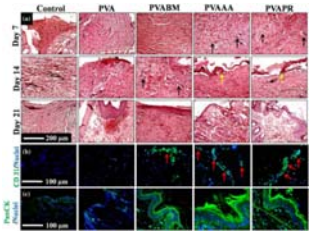
Nano silver coated SS pin

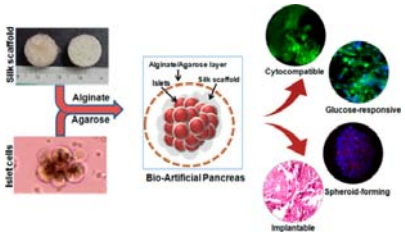
Chitosan as bone graft substitute

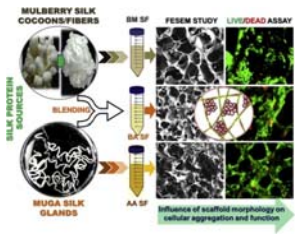


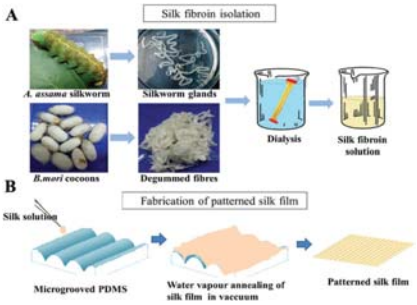
Bioceramic coated orthopedic implants for sustained, localized delivery of bisphosphonates to improve fixation

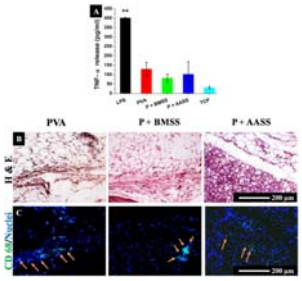




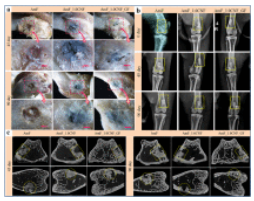


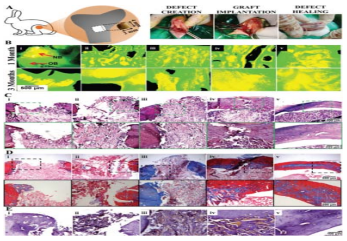






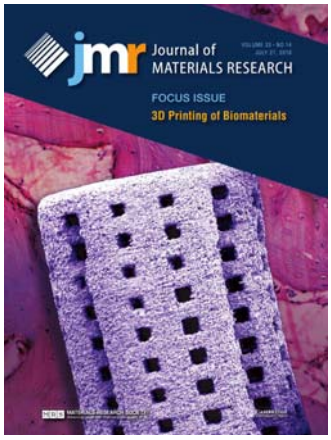
Silk-based materials for wound healing, vascular graft, bone graft etc.



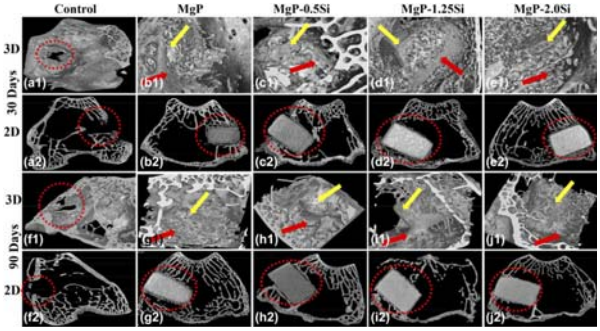


Silk-Bioactive Glass Composite Scaffolds

Restoration of nasal and ear defects using animal cartilage



3D printing of biomaterials in bone healing



Samit Kumar Nandi