NERC-TRE Introduction

As a national engineering research center, we aim to take work for the national science and industry development strategy to deliver social and economic impact through national leading science activities, innovative applied research and knowledge transfer services. Our mission is to deliver excellent responsive scientific research and commercialization of the outcomes for building up a national leading engineering center with international reputation in human tissue restoration and biomaterials research. The center is open to researchers and experts in both academia and industry around the world. You are always welcome to visit our center for collaboration or simply exchanging ideas. Our center also provides technical support including testing, consultation or training services to other institutes or companies from either domestic or oversea. With help and support from government and research community, we expect an organic growth and step change initiatives to deliver a growing and sustainable collaboration with industry partners to provide solid support for national strategy on promoting industry upgrade and development.

Director Yingjun WANG

作为国家级工程技术研究机构，中心的使命是服务于国家科技和产业发展战略规划，通过国内领先的科学研究、创新型应用研究和科技成果转化，为国家的经济及社会发展做出贡献。中心的目标是建设成一个在人体组织功能重建和生物材料研究领域国内一流，世界知名的国家级工程中心。本中心面向全球开放，我们诚挚邀请来自世界各地的专家学者前来中心访问或进行研究工作。同时中心向世界各国的科研同行及工业界同仁提供专业的测试、咨询以及培训服务。我们希望，在政府和协作单位的帮助和支持下，中心能够实现科技成果向生产力的高效转化，真正促进产、学、研之间的有机互动，为国家相关行业的产业升级和转型战略提供有力的技术保障和智力支持。

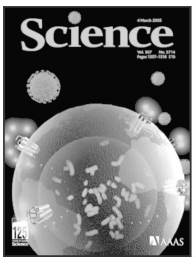
中心主任：王迎军

The National Engineering Research Center for Tissue Restoration and Reconstruction (NERC-TRE) is a national multiprogram science and engineering laboratory managed for the Ministry of Science and Technology of the People's Republic of China by South China University of Technology (SCUT). The center was established in 2009 with the solid support of various science and engineering disciplines from South China University of Technology. NERC-TRE's mission is to deliver scientific discoveries and technical breakthroughs that will accelerate the development and deployment of solutions in development of biomaterials and key technologies for human diseased tissue reconstruction and restoration, and in doing so create economic opportunity for the nation. The center aims at providing the advanced digitalized and personalized medical technology and the tissue restorative materials, such as skeleton, teeth, skin and cornea. NERC-TRE also performs other works including consultation services, industry training, and providing research and technical assistance to other organizations.

Many outstanding academic achievements and awards have been acquired by the NERC-TRE in recent years on novel biomimetic material for bone repair, integrated scaffolds for bone/cartilage repair, recognition and figure restoration of personalized medical information, and personalized implants for bone repair. The Biomedical Materials and Clinical Medicine Transformation Center was set up in NERC-TRE to enhance the collaboration with partners in medicine and healthcare industry as well as hospitals. The center is qualified for accepting postgraduate students including doctorate candidates and postdoctoral researchers. The joint-training project is being conducted through the collaboration between the center and clinical hospitals, universities and institutes both domestic and overseas. It has been recognized by our partnersin both industry and academiaas an excellent innovative education and training center for biomedical engineering graduatesat high standard to industry and research institutes.

1 NERC-TRE Facts and Figures

Research Grant: >45 million RMB
Papers Published: >490 papers (including Science, Biomaterials, Tissue Engineering and etc.)
Patents: >50 filed (20 granted)
Books: 2 academic monographs and 1 textbook
Awards: 1st prize of the Natural Science Award from the Ministry of Education, 1st prize of the Guangdong Provincial Natural Science Award, 1st and 2nd prizes of the Guangdong Provincial Technological Invention, and the Gold Award of the International Invention Fair.



The NERC-TRE is supported by the National Program on Key Basic Research (973 Program), the National High-Tech R&D Program (863 Program), the National Key Technology R&D Program for, the National Natural Science Foundation of China (NSFC), the National Outstanding Youth Foundation, the Ministry of Education, and the Scientific and Tech-

nological Programs of the Guangdong Provinces. The gross research funding is over 45 million RMB. The NERC-TRE has carried out a variety of pioneering studies included but not limited to the development of novel biomedical materials, optimization of drug carrier, systems for biomedical informatics and images, and personalized bone restoration technologies.

Total Land Area: 10 000 m^2

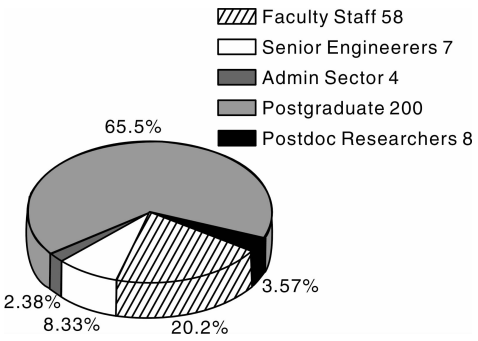
Equipment Cost: >40 million RMB, 154 pieces

Laboratories: 11 independent labs, 4 pilot production lines

The research center covers an area of 10 000 square meters and possesses equipment costing over 40 million RMB. There are 11 research and testing laboratories covering the research on biomaterials for restoring human tissues, tissue engineering, bio-assembly and biomimetic techniques, surface modification of medical implants, medical information and image processing, three-dimensional reconstruction, pattern recognition, manufacturing technologies of individualized implants, etc.

Faculty Staff: 58 total, 15 medical professors, 7 senior engineers, 8 postdoctoral researchers

Postgraduate Students: >200 (more than 50 doctoral candidates)



NERC-TRE has employed 58 faculty and staff as well as several adjunct medical professors and senior engineers, most of whom have oversea experiences and interdisciplinary research background. The center is qualified for training postgraduate students and doctorate candidates in fields of Biomedical Engineering, Materials Science and Engineering, Control Science and Engineering, Electronic and Information Engineering, and Mechanical Engineering. There are more than one hundred graduate students and postdoctoral researchers in the center. The joint-training project is conducted in collaboration with clinical hospitals, universities, both domestic and overseas. Furthermore, scholarships are provided to the meritorious students.

Commercialization: 3 technologies and products, 1 computer software copyright registered

Biomedical Materials and Clinical Medicine Transformation Center: 11 universities and research institutions, 18 hospitals and 29 enterprises joint

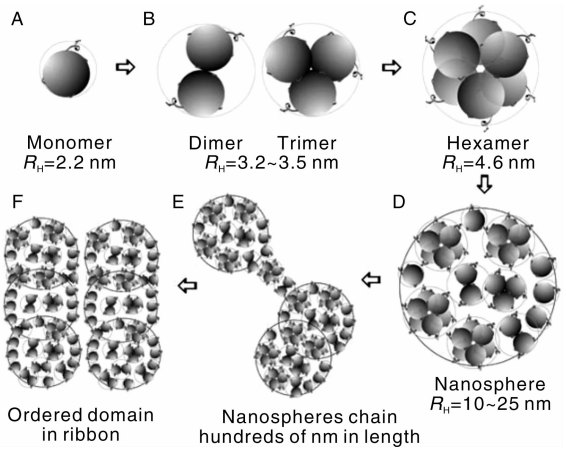
2 Scientific Research

NERC-TRE has acquired various grants from the National Basic Research Program of China (973 Program), the National High Technology Research and Development Program of China (863 Program), the National Natural Science Foundation of China (NSFC), the Science and Technology Program of Guangdong Province, and the industry. The center has carried out a variety of studies on the following subjects: new biomedical materials, manufacturing and surface modification technologies of medical implants, cell biology and tissue engineering, drug carriers, biomedical information and image processing, and personalized bone restoration technology.

In recent years, more than 490 scientific papers have been published, as well as two scholarly monographs. The number of published papers is continually increasing every year. The center holds more than approved 20 patents, and several prestigious awards including the First prize of Natural Science Award from the Ministry of Education, the First and the Second Prizes of Guangdong Provincial Science and Technology Award.

Biomineralization and Biomimetic Bone Substitute

In this study, unraveling the biomineralization principles in tooth formation would provide insight and inspiration for novel biomimetic materials design. In the near future, such materials could be employed for the repair of dental hard tissues. It is known that amelogenins, ameloblastins and enamelins are the major protein components in developing enamel matrix.



Personalized Human Tissue Restoration and Function Reconstruction

The supramolecularassembly of enamel matrix proteins plays pivotal roles in the regulation of enamel biomineralization. A systematic study is underway to understand the protein-protein and protein-mineral interactions. It is generally agreed that the proteins actively regulate mineral formation and their transformation, especially with carboxylic acid-rich regions. Besides the macromolecules, small organic molecules such as citrate are found in biological tissues and play important roles. We are studying biomimetic mineralization of calcium phosphates controlled by sodium citrate. Compared to a control group without citrate, the morphology of DCPD minerals was changed greatly due to the effect of sodium citrate. Understanding the interaction between this multi carboxylic

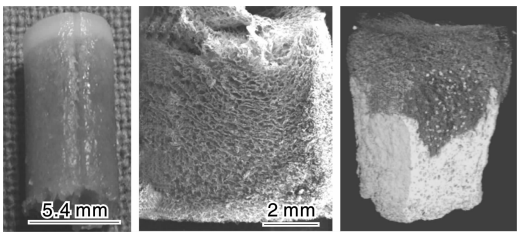
acid and Ca-P is important for developing biomimetic bone substitute.

Our research focuses on biomedical devices design and fabricating techniques for individual customization, including the computer-assisted analysis for damage and malformations of hard tissue, implant and fabricating methods for personalized human tissue restoration, and computer-assisted surgical procedures. The study is a combination of surface treatment, biomineralization, rapid prototyping, materials precision machining, image processing and 3 dimensional medical image reconstruction techniques. Following figure is the model for individual clinical diagnosis, made by Micmics and Solids Works.

Bone prostheses and related medical devices design and precision machining are provided for individual customization using reverse engineering technology. Shape and structure of prostheses are consistent with individual anatomic parameters, and the precision machining accuracy satisfies clinical requirements. There are more than 120 successful clinical cases using our products in The First Affiliated Hospital, Sun Yat-Sen University and General Hospital of Guangzhou Military Comand of PLA.

Gradient OsteochondralImplant

Regeneration of damaged articular cartilage is very difficult. This gradient osteochondral implant tries to mimic the cartilage regeneration environment of both biologics and biomechanics. The biologics environment was formed by the gradient top-down three layers composed by the collagen layer and two collagen/ hydroxyapatite (HA) layers with different HA loading. It's supposed, with this structure, when it is transplanted into the cartilage defect, a new subchondral bone would be conducted quickly into the bioactive bottom collagen/HA layer to substitute the removed sclerotic bone that destroyed the top cartilage regeneration biomechanics environment.



The in-vivo experiments showed that the new subchondral bone started to form 4 weeks after the gradient osteochondral scaffold had been implanted. New cartilage was also observed to regenerate. But the histological zonal structure was still different from the natural cartilage as the reconstruction process was not completed. Considering the complicated pathology factors that cause cartilage matrix degeneration inside osteoarthritis patients' joint capsule, this gradient implant could be used as a carrier both for a long time anti-inflammatory drug delivery system and chemokines delivery system promoting inner source stem cell migration.

3 Laboratory-Directed R&D

The NERC-TRE, focusing on biomedical information and image processing, personalized design and manufacturing, functionalized biomaterials preparation and tissue engineering, provides enterprises with a number of innovations that have commercial value. The center has regularly collaborated with related enterprises and hospitals and several co-laboratories have been established. A Biomedical Materials and Clinical Medicine Transformation Center was set up in Dec. 2009 at the center. 11 universities and research institutions, 18 hospitals and 29 enterprises became the cooperative partners. The alliance aims at promoting the development and application of new products provided with specialized staff, advanced equipment, and pilot production lines, and brings the advantages of research institutes, medical institutions and enterprises fully into play.

With the solid support from NERC-TRE and other partners in academia, healthcare industry and clinical hospitals, the center has built up a strong scientific research team with several well equipped laboratories and production lines. Many national leading joint engineering research laboratories, commercialization centers, demonstration centers, student innovation workshops, animal experiment labs, clinical demonstration base have been set up in the center. Project oriented research activities have been conducted in order to accelerate the process of translation of the research outcomes into the commercialized products by setting the complete research-translation-industry strategy by collaboration with partners in industry. One aim of the center is to provide excellent engineer graduates with multidiscipline backgrounds to meet the need from the rapid development of biomaterials industry in China. During recent years, the translation center has acquired various grants from the National Basic research Program of China (973 Program), the National High Technology Research and Development Program of China (863 Program), the national science and technology support program or key project of National Natural Science Fund, and the funds reach up to 200 million RMB. The center has 5 union lab built with partners, 5 demonstration base of scientific research outcome translation, 5 innovation practice centers for college students and 3 clinical trial and experiment centers.

4 Successful Commercialization

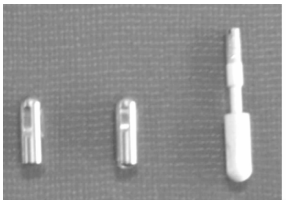
With the strong support from the scientific researchactivitieson biomedical information and image processing, personalized design and manufacturing, functionalized biomaterials preparation & tissue engineering in NERC-TRE, a number of innovations have been commercialized with series of products successfully developed in recent years. SFDA approvals have been obtained for several products and many under clinic trail.

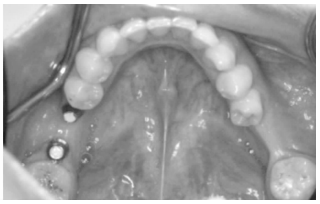
The Bioactive Glass Products

Machinable artificial bioactive crystal vertebral disc and porous bone infill are used to treat spinal stenosis and bone defects caused in bone tumor surgery. It has been issued 3 invention patents and was awarded the second prize of Guangdong Provincial Medicine & Technology Progress.

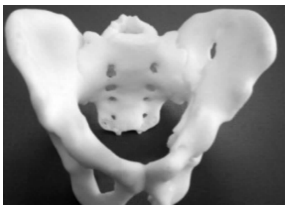
Highly Bioactive Dental Implants

The dental implant, with high biological activity, is utilized in immediate implantation. This achievement has been nominated by the Ministry of Education, won the 2nd prize of the National Science & Technology Invention Award and was granted two invention patents. The product is now under clinical trial and mass production has been approved.





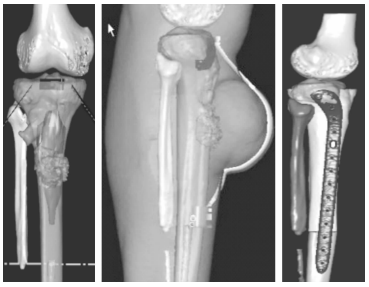
Personalized Bone Replacement



Our researchers recognized the need for personalized design and precise manufacturing of different types of bones. The restored bones fit the personalized anatomical characteristics and meet the requirement in surgical operation. This innovation has been clinically employed in 120 cases in the 1st affiliated hospitals of Sun Yat-Sen University and Guangzhou General Hospital of Guangzhou Military Region for.

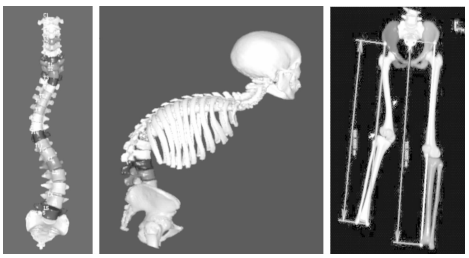
Digital Bone Reconstruction

Our digital bone reconstruction technique has been employed in the 1st affiliated hospitals, Sun Yat-Sen University and the Guangzhou General Hospital of Guangzhou Military Region, and was recognized with the second prize of Army Science and Technology Progress award.



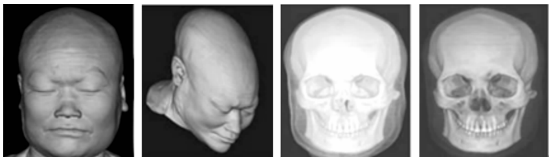
Bone Anatomy Parameter 3-D Measurement Technique

A database is set up in the clinic includes the bone and joint models, such as the spinal column, and lower and upper limbs of normally weighted people of different genders and heights. This technique has been utilized in several affiliated hospitals of Sun Yat-Sen University, Xijing Hospital of the Fourth Military Medical University, 301 Military Hospital, and Guangzhou General Hospital of Guangzhou Military Region.



Medical Information Reconstruction, Identification and Visualization System

The technology has been utilized in several affiliated hospitals of Sun Yat-Sen University, Xijing Hospital of the Fourth Military Medical University and Guangzhou General Hospital of Guangzhou Military Region. This innovation has been granted one registration of software copyright and one invention patent.



5 International Collaboration

With the support of the International Partnership Project and Innovation Project of Postgraduate Education, the NERC-TRE has established scientific collaborations with overseas universities like University of Florida (US), Georgia Institute of Technology, University of Southern California, University of Liverpool (UK), Kyoto University (Japan), Vigo University (Spain), Nanyang Technological University (Singapore), University of Hong Kong, Hong Kong University of Science and Technology; and domestic clinical hospitals such as Peking University Health Center, the 301 Military Hospital, the Fourth Military Medical University, and the West China Hospital of Sichuan University.

Prof. D. F. Willianms, currently the chief editor of Biomaterials was employed as part-time professor in South China University of Technology

A doctoral training base jointly built with Nanyang Technological University, Singapore

Prof. Yingjun WANG and Prof. Jane Harding, the vice chancellor of the University of Auckland, signed a comprehensive cooperation agreement

(华南理工大学曹晓东教授供稿)