PERSPECTIVE

Chinese Orthopaedic Research Society and its future focus on translational research

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Summary The gap between orthopaedic basic research and clinical research has been reduced with the development of modern research technology and the well-accepted concept of translational medicine. The personnel involved in orthopaedic research realise more clearly than ever that basic research should be patient centred and clinical-application oriented. The mainstream of orthopaedic research has been gradually changing from bench-to-bedside to bedside-to-bench-to-bedside. This paper reviews the history of the Chinese Orthopaedic Research Society and its future development with a focus on translational medicine in musculoskeletal research and education.

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History of Chinese orthopaedic basic research

Chinese orthopaedic research dates back to ancient times. Its achievements have made great contributions to the development of Chinese medicine, especially in the treatment of musculoskeletal injuries, and have gained respect throughout the world. The book Prescriptions for Fifty-two Diseases, written around 475 BC, recorded the first realignment of fracture bone using traction splints, external fixation using small splints, and dynamic traction splints for intra-articular fractures of phalanges in the hand. Secrets of Treating Wounds and Bones and Total Effective Formularies for Emergency of the Tang Dynasty collected thousands of prescriptions and therapies for bone injuries. The pharmacologist Shizhen Lee’s Compendium of Materia Medica of the Ming Dynasty made a careful study of 1892 herbs; of which, 170 can be used in orthopaedic medicine [1–3]. Nowadays, Chinese orthopaedic researchers are working hard to keep contributing to modern scientific orthopaedic research combined with traditional Chinese medicine.
Five stages in the development of the Chinese Orthopaedic Research Society

In 1980, the Chinese Medical Association organised the first national meeting of orthopaedics in Tianjing, China, where it announced the establishment of the Chinese Orthopaedic Association (COA) \([1,2]\). Five years later, at the second national meeting of the COA in 1985, the Chinese Orthopaedic Research Society (CORS) was founded with the aim of promoting, supporting, developing, and encouraging research in clinical orthopaedics, musculoskeletal diseases, and its related disciplines. In the past 30 years, CORS has played a leading role in advancing the integration and transformation of research resources and achievements nationwide, organising educational activities and facilitating collaboration among research groups. As a professional, scientific, and medical organisation, the importance and impact of CORS extends increasingly. The board of CORS now consists of over 50 top and leading clinician-scientists and basic scientists from Mainland China, Hong Kong, Macau, and Taiwan. The development of CORS may be divided into the following distinct stages:

Stage I (before 1979)
Before 1979, there was no independent orthopaedic research organisations in China. In addition, there was a lack of professional orthopaedic research institutes including research laboratories and personnel, and awareness of the importance of conducting basic and clinical research among orthopaedic surgeons.

Stage II (1978–1982)
In 1978, China restarted the enrolment of orthopaedic postgraduates, which catalysed the development of orthopaedic research laboratories, although most of these laboratories focused more on clinical follow up and less on basic research.

Stage III (1982–2001)
In 1985, CORS was founded, which marked a new era in Chinese orthopaedic research. During this period, orthopaedic research in China began to gain special emphasis and some well-known national hospitals had set up laboratories for basic orthopaedic research. Although CORS was in its initiation stage with limited impact and inadequate professional experience, it put great effort into organising activities, such as combined academic activities with other influential orthopaedic societies.

Stage IV (2002–2006)
With the development of CORS, it held the Sixth National Orthopaedic Research Conference in 2003 in Shanghai (China) independently (the previous 5 conferences were jointly organized by COA and CORS). Since then, many academic meetings and educational events have been held every year, which greatly contributed to the progress of orthopaedic research in China. At the same time, almost every major hospital and medical college had its own orthopaedic research laboratory or institute. Furthermore, an increasing number of orthopaedic surgeons realised the significance of and committed to orthopaedic research. Subsequently, the number of professional staff in orthopaedic laboratories grew rapidly. However, the weaknesses of CORS at this stage were obvious, such as the basic research teams could only conduct advanced research projects at a limited or less comparative level. In addition, there were no clear and distinct research directions and the awareness of transitional medicine and its related research system needed awakening.

Stage V (2006–present)
Orthopaedic research in China began to move into high gear. In 2006, the society formally announced its English name as the Chinese Orthopaedic Research Society and became a member of the COA (Figure 1). The large number of participants from home and abroad made the CORS annual meeting an influential academic event in the medical field (Figure 2). The increasing collaboration with leading orthopaedic research groups has enabled Chinese orthopaedic research to keep abreast of the international trends in orthopaedic development. Nowadays, there are over 30 orthopaedic research institutes in China, with a total of 2000 professional research staff. In addition, there are more than 3000 postgraduate students enrolled every year, who focus on different research directions based on their own expertise and interests. Encouragingly, there have been significant achievements made in research on peripheral nerve regeneration, bone graft implantation, spinal degeneration diseases, musculoskeletal ageing, stem cell and tissue engineering, scoliosis, trauma, sports medicine, three-dimensional printing, orthopaedic implants and devices, and traditional Chinese medicine for orthopaedics.

Current research focuses of orthopaedic basic research in China

Although there are numerous directions of orthopaedic basic research in China, data based on the National Natural Science Foundation of China (NSFC) have revealed that there are two major aspects, ageing and the musculoskeletal system, and musculoskeletal tissue regeneration, which gained the largest (approximately 20-fold) growth in funded projects and have made compelling achievements.

Ageing and the musculoskeletal system
The ageing population is increasing rapidly and has become a major socioeconomic and health burden worldwide. When it comes to orthopaedics, there appears to be a close correlation between ageing and musculoskeletal diseases. Osteoporosis, intervertebral disc degeneration, and degenerative osteoarthritis represent the highest incidence among the age-related diseases. In recent years, we have focused on the study of stem cell therapy for osteoporosis, differentiation of bone-related cells, targeted treatment of
the bone microenvironment, noncoding RNA, interaction of osteoblasts and osteoclasts, and large-scale clinical investigation of postmenopausal women with osteoporosis, and believe that the scientific and technical breakthroughs have great potential for the prevention, diagnosis, and treatment of osteoporosis.

Although China has a long history in treating degenerative osteoarthritis, Chinese basic researchers have only worked on its pathogenesis in recent years. We have focused on finding the key factors in osteoarthritis from genetics to bone microenvironment, and have made some encouraging progress.

Intervertebral disc degeneration accounts for most spinal degenerative diseases pathologically, but its mechanism remains unclear, which make the diagnosis and treatment of spinal degenerative diseases difficult. The current belief is that it is a multi-mechanism medical problem. At present, several research institutes in China are investigating the mechanism of inflammation, immunology, and stem cell senescence, and propose potential medical solutions for prevention and treatment. Their findings have drawn attention from peers worldwide.

**Musculoskeletal tissue regeneration**

Regenerative medicine is a new branch of medicine, dealing with the process of replacing, engineering, or regenerating human tissues and/or organs to restore functions. Regenerative medicine involves the engineering of damaged tissues and organs via stimulating the patient’s own repair mechanisms to heal previously irreparable tissues or organs. In China, the related, stimulating pioneer work originated from the subspecialty of limb transplantation. Within a short period of development in orthopaedics, regenerative medicine has flourished in the fields of internal fixation material, engineering bone substitutes, and stem cell therapy. The promising prospect of musculoskeletal tissue regeneration attracts many orthopaedic basic/clinic researchers and engineers in China to...
focus research on materials for tissue engineering, regeneration cytokines, stem cells, and bone engineering. In particular, it is worth mentioning that the study and application of digital orthopaedics is gaining popularity and has become a key motivation for research. Digital orthopaedic technology is a combination of digital information technology and clinical orthopaedics. The achievements of finite element analysis, rapid prototyping, three-dimensional printing, CAD/CAM (computer-aided design/computer-aided making), computer-assisted navigation, and robot-assisted surgery, have made orthopaedic clinical practice more precise, personal, and intuitive.

Strengths and weaknesses of Chinese orthopaedic basic research

Analysis of the strengths and weaknesses of orthopaedic basic research in China may provide a reference for our future development. As part of a SWOT (strengths, weaknesses, opportunities, and threats) analysis, we recognise that rapid national economic growth has brought great opportunities, but which are accompanied by threats that we must overcome.

Strengths

The integration of basic research units into clinical orthopaedic departments is one of the unique aspects of orthopaedic research in China. It facilitates the direct communication and collaboration between basic scientists and surgeons, and allows them to plan research projects jointly and apply the results to health care, known as the bench-to-bedside and bedside-to-bench-to-bedside model [3,4]. Another asset is that due to the huge population in China, there is a large quantity of clinical data for clinical research after proof-of-concept preclinical studies have been performed.

Weaknesses

Most basic science research follows the international trend, and there is a lack of innovative projects and world-leading research teams. The Chinese orthopaedic industry lags far behind the United States (US) and other developed countries in research and development (R&D) of medical products for orthopaedic applications. For example, there is no domestically made, high-quality artificial joint on the Chinese market. A similar situation occurs in relation to spine and trauma products. These facts reveal that there is a low level of translational medicine in China, which along with the inadequate number of technicians and designers, limited level of mechanical processing and biological materials, and lack of clinical implant evaluation centres, indicates that there is a long way to go before Chinese basic science researchers can keep abreast of the international cutting-edge advances.

The large amount of data have not been fully and efficiently used due to a lack of multicentre clinical research teams.

The ability to identify weaknesses is important in order to work out solutions step by step to effectively promote translational research. Scholars and industrial sectors in China are now making great efforts to counteract the “valley of death”, which includes: (1) organising the milestone event—Annual Congress of Orthopaedic Translational Research in Shanghai (Shanghai OTR); and (2) the readjustment of large national research programmes managed by the Ministry of Sciences and Technology (MOST), partially towards translational programmes. This is reflected in China’s 13th Five-Year Plan with a new initiation in joint R&D grant applications to promote and enhance collaborations among industries, universities and research institutions, venture capitals, regulatory bodies, markets, or end users [5,6].

Opportunities

We are currently at a good time to develop and enhance orthopaedic research. Opportunities include: (1) rapid growth of the national economy and, accordingly, a rapid increase in funding opportunities for research; (2) increasing number of returnees after receiving education and research training in leading countries for orthopaedic and related research; they have become a significant force or leaders in orthopaedic research and education in China; (3) significant enhancement of local, national and international collaborations as a result of the above two key elements; and (4) stronger leadership in the CORS community over the past 2 decades.

Threats

The rapid increase in research funding creates distraction and/or imbalance in energy distribution for conducting research and spending time on frequent grant proposal preparation at various levels. When threats refer to external factors in industrial sectors, both preclinical and clinical researchers are under great pressure to secure funding for internal performance assessments. The threats we are currently facing may include: (1) less time to concentrate our energy on clinical and laboratory work; (2) a lack of strategic funding support for promoting translational research and staff development, especially in teaching and research hospitals where translational medicine is the focus of R&D; (3) too much commitment to academic meetings organised by various academic societies, research institutions or units, and teaching hospitals—this is particularly true for leading academic institutions in orthopaedic research; and (4) regulatory issues for R&D of medical devices and drugs that most researchers are not familiar with. This is also known as a significant difference between scientific publications and regulatory bodies.
Future of Chinese orthopaedic basic scientific research

With the emphasis on the importance of basic medical research and translational medicine in China’s 13th Five-Year Plan, CORS is actively playing its role and draws the blueprint for the national orthopaedic basic research plan [5,6]. CORS supports collaborations between/among preponderant research teams, so that they can take advantage of each other’s strengths to make breakthroughs in their related fields and expand their influence within the discipline.

International exchange will be promoted. The bidding for the 2016 International Combined Meeting of Orthopaedic Research Societies has been approved by the International Combined Orthopaedic Research Societies (ICORS) and will take place in Xian (China) in September 2016 [7,8]. The meeting aims at stimulating orthopaedic and musculoskeletal research in fields of biomedical engineering, biology, chemistry, and veterinary and human clinical research. The world-leading professionals will gather together to share their latest advances and discuss topics including results on clinical trials and the current trends of orthopaedic research, which may have the potential to change the current clinical practice.

The strategic partnership between CORS and International Chinese Musculoskeletal Research Society (ICMRS) will be deepened. ICMRS is a nonprofit professional organization composed of scientists of Chinese heritage and other international scholars in the field of musculoskeletal research and its related areas [9]. ICMRS has set up a China Development Committee, which is in charge of the cooperation between Mainland China, Hong Kong, Macau, and Taiwan. Currently, there are 18 combined research centres and several meetings or academic events have been held that have yielded fruits.

The connection with the other societies of the COA will be strengthened [10]. By adopting the model of the Annual Meeting of American Association of Orthopaedic Surgeons (AAOS)/Orthopaedic Research Society (ORS) in the US [11-13], the annual meeting of CORS opens 1 day before the COA annual meeting and closes on the same day, which strives to facilitate the exchange of ideas and promote collaboration among scientists and clinicians [14]. There will be more emphasis on translational research, as this is a global trend as listed in the ORS 2020 [15-17] and our ultimate goal of orthopaedic research [3,4,11,18]. CORS has been invited as the Guest Nation of 2017 ORS in San Diego, CA, USA (Figure 3).

In order to enhance the function of CORS, similar to the ORS, the Society will start to form several functionalised committees to realise its mission and vision, including: (1) membership committee for promoting orthopaedic research; (2) preclinical and clinical research committee for enhancing collaborative research; (3) education committee for establishing systemic basic and clinical research training programmes; (4) industry engagement committee for enhancing translational research and medical device, implant, and drug development; (5) nominating a committee for identifying motivated and talented younger researchers to engage in long-term sustainable development of CORS; (6) international committee for liaising with international sister societies for collaboration; and last but not least (7) if feasible, a financial committee within the COA, similar to the relationship between the ORS and AAOS.

CORS and translational medicine

The initial intentions of translational medicine are to shorten the process from basic research to clinical applications and promote the use of new technologies, drugs, and therapies for patients. There are more basic orthopaedic researchers who have begun to realise the significance and importance of
translational medicine and who are starting to dedicate themselves to the cause [2,4,14]. Although translational medicine is an emphasis in China, it is still at the initial stage and more awareness should be raised among Chinese researchers. For example, the artificial cervical disc has been widely used in Chinese hospitals since it was first imported in 2002. However, there is still no domestically made counterpart at present, which can be attributed to the limited capability of basic research. In fact, the first artificial cervical disc was developed by Chinese scientists in 1984, but it was never put into practice for 25 years. Fortunately, with the establishment of key national translational medicine centres, translational research has speeded up in China. It is encouraging that CORS has recognised translational research as its main focus in the new blueprint, although there are many obstacles to overcome [14].

Current status of orthopaedic translational research in China

The introduction of orthopaedic translational medicine in China was relatively late, but its development has been rapid [2,4,14]. In the National 12th Five-Year Plan for Science and Technology Development, translational medicine was adopted as a major strategy in the medical field in China. In the past 5 years, more than 50 translational medicine institutions have been established in China, covering stem cells, regenerative medicine, drug development, the musculoskeletal system, and most key medical disciplines [4,17]. The investment from the government and business companies is increasing precipitously. Every year, academic conferences on orthopaedic translational medicine are being held in most big cities. The most striking meeting is the International Congress on Orthopaedic Advanced Techniques and Clinical Translational Research sponsored by an academician, Professor Kerong Dai, which has been held consecutively for 10 years in Shanghai. This meeting has had a profound influence on pushing translational medicine forward in China. Professor Dai is one of the pioneers of orthopaedic translational research in China, whose monograph, *Translational Medicine—Concept, Strategy and Practice*, is acclaimed as a major reference in translational research [19]. However, there are difficulties in setting up an efficient operating system for a new branch of medicine that is of pressing need. This requires collaboration among many disciplines and administrative offices. Recruiting and cultivating talent takes time. In addition, habits such as research mode and evaluation criteria need further improvement.

Journal of Orthopaedic Translation

The *Journal of Orthopaedic Translation* (JOT) commenced its publication in 2013 [20,21]. It is the first and only journal that is dedicated to the field of orthopaedic translational research. JOT covers topics including biotechnology, biomaterials, bioengineering, disease-specific biomarkers, cell and molecular biology, genomics, bioinformatics, immunocytochemistry, molecular imaging, new drug development, regulation/policy making, and any musculoskeletal related translational research. The launch of JOT is a monumental step in the advancement of musculoskeletal care by bringing cutting edge knowledge to the forefront and allowing pioneers of orthopaedic translation to exchange and mutually enhance expertise. CORS has established a partnership with its holder, the Chinese Speaking Orthopaedic Society (CSOS) [22] and the ICMRS [9], and appeals to CORS members to submit high-quality manuscripts.

Conclusion

China has a long history of orthopaedic research, documented in the history of traditional Chinese medicine for musculoskeletal injuries and repair. Exchange and cooperation with developing countries stimulate the development of basic research and its translation. With the involvement of more clinical experts and scientists after their study and/or training abroad, Chinese orthopaedic research has made remarkable achievements in recent years. Patient- and clinic-oriented orthopaedic translational medicine is the future focus of Chinese orthopaedic basic research. The main aim of this review is to demonstrate that Chinese orthopaedic research has a bright future, if the recommended changes outlined above are addressed.

Conflicts of interest

All contributing authors declare no conflicts of interest.

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