

# Scoliosis in China: History and Present Status

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**Key words:** China; Current Status; History; Scoliosis

Scoliosis is a three-dimensional (3D) spinal deformity involving one or more spine curvatures with vertebral rotation. In the past 30 years, Chinese spine surgeons adopted international advanced technology and concepts, took advantage of abundant Chinese patient resources with severe deformity, and developed novel ideas and techniques, which promoted the development of the diagnosis and treatment for scoliosis.

## EPIDEMIOLOGICAL SURVEY OF SPINAL SCOLIOSIS

As earlier as 1986, Chinese researchers conducted survey for scoliosis. Peking Union Medical College Hospital (PUMCH) screened 21,759 children aged 8–14 years in Beijing.<sup>[1]</sup> The results showed that the prevalence rate of scoliosis was 1.06%. Among all the patients, 87.5% were diagnosed as idiopathic scoliosis. Since the middle of the 1990s, lots of similar census appeared, mainly in Guangzhou, Shanghai, Beijing, and other big cities. After 2010, it began to spread the whole country, Heilongjiang, Xiamen, Foshan, Wenzhou, Wuxi, Sanya, Xi'an, Kunming, and other areas performed large sample screening studies. The incidence of scoliosis varied from 0.6% to 2.0%. In all of the patients with scoliosis, idiopathic scoliosis took up about 90%, and others included congenital scoliosis, neuromuscular scoliosis, and neurofibromatosis. These data provided a baseline condition of Chinese scoliosis patients and laid a foundation for making the corresponding health policy and treatment guideline.

## TREATMENT OF SCOLIOSIS

### Conservative treatment

Conservative treatments for scoliosis in China include acupuncture, casting, and brace, which were not started until 1986. Among them, brace plays the major role in the nonsurgical treatment of scoliosis in China.<sup>[2]</sup> The main problems of brace treatment in China were as follows: (1)

Most of the brace centers had lack of professional training, physician support, and practice standardization. (2) Clinical and basic researches of brace treatment were limited. (3) There are still many surgeons who underestimated the role of conservative treatment and therefore inappropriately expanded surgical indications.

### Standardization of surgical treatment

In the late 1960s, Harrington's internal fixation was developed, and then Luque technique appeared in the 1970s. However, during this time, casting was the most common treatment of scoliosis in China, which was obviously lagged behind. After the reform and opening up policy in 1981, PUMCH introduced foreign advanced technology and surgical instruments (Harrington, Luque, and other techniques) into China and made the equipment nationalized to treat scoliosis. At that time, due to lack of technical standardization and unstable quality of domestic medical equipment, there are often inappropriate choice of surgical segments, Harrington's rod fracture, hook decoupling, *etc.*, In 1983, PUMCH held the first Chinese spine deformity training course. Since then, the fixation techniques of scoliosis in China got gradually standardized and the hospitals that treat scoliosis developed rapidly. In the mid-1990s, PUMCH introduces the most advanced Cotrel-Dubousset (CD) 3D correction technology and concepts, which further led to considerable progress of scoliosis treatment in China.

However, with the increasing use of 3D internal fixation systems, many researchers found trunk unbalance and

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**Received:** 27-07-2017 **Edited by:** Ning-Ning Wang  
**How to cite this article:** Qiu GX. Scoliosis in China: History and Present Status. Chin Med J 2017;130:2521-3.

Access this article online

Quick Response Code:



Website:  
www.cmj.org

DOI:  
10.4103/0366-6999.217081

decompensation after selective fusion. These new problems led spine surgeons to recognize the shortcomings of King's classification. In 2001, Lenke *et al.* set up a new classification for idiopathic scoliosis, which is more comprehensive with the selective fusion criteria. However, Lenke's classification was based on the definition of structural curve which arose many conflicts, with no clear guidelines for the treatment strategy for nonstructural curve. Therefore, PUMCH summarized the characteristics of idiopathic scoliosis cases in China, and established PUMC classification, which was published in Spine in 2005.<sup>[3]</sup> PUMC classification provided a clear strategy for surgical approaches and fusion range for each subtype and was significantly valuable for the surgical plan design.<sup>[4]</sup>

## Improvement of surgical techniques

### Posterior operation

In 1962, the first generation of posterior internal fixation system was developed by Harrington. In 1976, Luque invented the Luque wire, which was the second generation of the posterior internal fixation system. However, it lacks axial distraction forces and cannot perform derotation. In 1984, Cotrel and Dubousset introduced their segmental fixation system, known as the CD system, which was considered as the first 3D internal fixation system. TSRH<sup>®</sup>, Moss-Miami, Cotrel-Dubousset Horizon, and Isola and other systems are then generated. All these internal fixation systems were introduced and widely used in China.<sup>[5]</sup>

The third-generation orthopedic internal fixation system was developed from hook structure to the screw-hook hybrid structure, which has become the mainstream of internal fixation of spine surgery in China. Recently, the accuracy of pedicle screw implantation has been improved and the complication has been significantly reduced with the development of the computer-aided surgery navigation system, which integrates clinical surgery with computerized processing of medical image, 3D visualization, medical robot, and 3D navigation system.<sup>[6]</sup>

### Anterior operation

The advantages of anterior approach include the mechanical advantage of applying corrective force on the lateral translation and rotation of vertebral body, correcting scoliosis by shortening instead of lengthening the spine, avoiding late crankshaft phenomenon, and saving fusion segments.<sup>[7]</sup> However, with the development of posterior spinal correction techniques and internal fixation system, the anterior approach presents a downward trend due to its complicated procedures and frequent complications. However, for the lumbar scoliosis and posterior revision surgery, anterior approach still has its advantages.

### Hemivertebral/vertebral resection for congenital scoliosis (kyphosis)

For congenital scoliosis and kyphosis caused by hemivertebra, the hemivertebral resection can directly remove the deformity and pathology, and therefore it is the most ideal method. However, the hemivertebral resection is technically demanding, and therefore its domestic wide application was

relatively late. The posterior one-stage hemivertebral resection has advantages of less operation time and less risks for infection caused by patients' position change during combined approach surgery, but it has high technical requirements.<sup>[8,9]</sup> It has been used widely in China only in the recent years.

### Osteotomy treatment of severe rigid scoliosis

Treatment of severe rigid scoliosis remains to be the great challenge. In the past, second-stage posterior fixation after anterior release, Halo-pelvic traction after anterior release, has been attempted with less satisfying results. In the recent years, many domestic centers adopted vertebral column resection for the treatment of severe rigid scoliosis.<sup>[10]</sup> Vertebral resection, decompression, and 360° fusion can be completed at one stage, which reduces the number of operations and avoids the spinal cord injury caused by dislodgement of anterior bone graft in the second-stage posterior surgery. However, it has more intraoperative blood loss, longer operation time, and more complications.<sup>[11]</sup>

### Concept and treatment of early-onset scoliosis

The surgical treatment of early-onset scoliosis (EOS) mainly focused on nonfusion techniques which are described as follows:

1. Rib-spreading technique: Vertical expandable prosthetic titanium rib (VEPTR) can improve lung development before 5 years old and limit the progress of scoliosis. Some hospitals in China have carried out this technique, but found that there are some complications, such as device displacement, rib fracture, abnormal gravity line of spine, skin rupture, and nervous system damage.<sup>[12]</sup>
2. Posterior growing rod technology: Single/double growing rod aims to correct scoliosis without affecting the growth of the spine. However, this technique needed several operations and had complications such as wound infection, poor healing, and implant failure.<sup>[13,14]</sup> In 2012, Akbarnia and Kenneth MC Cheung<sup>[15]</sup> reported the primary clinical results of treating EOS with a new magnetic control growing rod, which reduces the trauma of repeated distraction surgeries.
3. Spinal growth regulation-Anterior or endoscopic staple technique, tethered technique, attempts to limit the growth of vertebral bodies asymmetrically to correct the scoliosis and prevent its progress. However, the long-term effect needs further observation. There are also domestic experimental studies in China.

## BASIC RESEARCH OF SCOLIOSIS

The basic research of scoliosis in China was started relatively late. Since 2000, it was developed rapidly with the improvement of surgical techniques. As for idiopathic scoliosis, more than 20 genes have been found being differentially expressed including collagen, *TGF-β*, *FGF*, and *SOX9*. With the popularity of genetic research techniques, polymorphism of *IGF1*, *MTNR1B*, *ESR1*, *CALMI*, *PAX1*, and *WNT3A* has been reported to be associated with idiopathic scoliosis. As for congenital scoliosis, *TBX6* deletion associated with high-risk alleles

was reported in 2015, which was exerted a huge impact at home and abroad.<sup>[16]</sup>

### International academic position

With the deepening of China's reform and opening, academic exchanges are becoming more frequent at home and abroad. The Spine Deformity Study Group-China was founded in 2007. In May 2009, the Scoliosis Research Society (SRS) held a regional world-class conference in Beijing, China. The meeting was the first time that SRS held international conference committee in Asia. Since then, more international scoliosis conferences were held in China. Many Chinese spine surgeons gave lectures to introduce Chinese experiences at the top international academic conferences, such as SRS annual meeting, IMAST annual meeting, and Euro-spine annual meeting. Through academic exchanges, the international academic position of our country has been raised.

### Future expectation

In China, scoliosis correction has developed rapidly for 30 years with fruitful results. In the future, with the development of internal fixation materials, imaging technology, computer science, and precision medicine, scoliosis treatment in China will achieve greater progress.

The correct classification of deformities is beneficial to academic exchanges and standardized treatment among surgeons; Advances in imaging technology will allowed surgeons to more accurately evaluate the type and extent of spinal deformities; The invention of the new internal fixation technique will make the fixation more reliable and safer, meanwhile reduces the fixed range; Minimally invasive techniques will reduce surgical trauma; Navigation techniques help surgeons perform operations safely in complex site with accurate fixation; Intraoperative spinal monitoring techniques greatly increased the safety of surgery; The development of 3-D printing materials provides more options for complex malformations; Gene based accurate medical treatment model will greatly promote the development of individualized treatment. In summary, the diagnosis and treatment of scoliosis will continue to make breakthroughs and develop individualized therapies in China. Expectantly, it will stand rock-firm in the field of spine surgery around the world.

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