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A MAGEC Approach to Treating Childhood Scoliosis

Most children with early-onset scoliosis (EOS) who have surgically implanted growing rods dread returning to see their doctors — because it often means another surgery to adjust the rods. That was not the case, however, for 6-year-old Jeremiah Knowlton, when he visited his scoliosis surgeon in August 2014.

That’s because Jeremiah — who developed a 75-degree curve in his spine in the first few years of his life — was the first patient in New York City to receive magnetically controlled spinal rods. Called MAGEC®, the treatment involves the surgical placement of growing rods in the child’s spine which can be adjusted every few months afterward during a routine outpatient visit using a remote-controlled device applied to the child’s back.

“You can know within a tenth of a millimeter how much you’re lengthening the rods,” notes Michael Vitale, MD, MPH, Co-Director of the Division of Pediatric Orthopaedic Surgery and Chief of the Pediatric Spine and Scoliosis Service at NewYork-Presbyterian/Morgan



Michael Vitale, MD, MPH, uses the MAGEC external controller to lengthen growing rods in the spine of Jeremiah Knowlton, 6, who was born with scoliosis.

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Pediatric mobile robots help children learn how to navigate using force-feedback joysticks.

Robotic Devices Lend a Helping Hand

Most people can reach for a cup of coffee that they are not looking at and successfully bring it to their mouths. But for people with cerebral palsy who have hemiplegia, that proprioceptive skill is missing. They may not reach the cup at all, or if they do grasp it with the involved arm, they may end up tipping the cup over. Moreover, the lack of control on the affected side often gets progressively worse as these patients learn to favor the dominant side.

To improve that scenario in hemiplegic children with cerebral palsy, clinical investigators are teaming up with engineers to devise a robotic assistance device to “retrain their brains,” with the goal of enhancing function on the involved side of the body. Strapped to the forearm, the device — which is in its earliest stages of development and is supported by funding from Columbia University’s Irving Institute for Clinical and Translational Research — is designed to provide auditory and vibratory “cues” (buzzing noises and feelings) to the patient so he or she will know where the arm is in space and learn to move the arm correctly. Over time, the goal is to get the patient to use the less functional hand more frequently, to retrain neural circuits to restore impaired proprioception, and to facilitate activities of daily living.

“Patients with hemiplegia don’t have spatial control,” explains Joseph Dutkowsky, MD,

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Robotic Devices Lend a Helping Hand (continued from page 1)

Associate Medical Director for the Weinberg Family Cerebral Palsy Center at NewYork-Presbyterian/Morgan Stanley Children's Hospital. "Can this device tell them that a nearby cup they want to grab is tilting and about to spill? That's the skill that it's designed to help. Our hope is that the device will take advantage of the brain's plasticity over time — allowing the affected side of the patient's body to become more functional — and eventually they won't need the device."

The current treatment for hemiplegia includes physical and occupational therapy, which typically require patients to leave their homes to receive care at an office or clinic, and this can be challenging for their parents. Hiroko Matsumoto, MA, Director of Clinical Research at the Weinberg Family Cerebral Palsy Center, notes that the portability of the arm device means that patients can use it at home. The investigators are collaborating with Sunil Agrawal, PhD, Professor of Mechanical Engineering and Rehabilitation Medicine at Columbia University, to design and evaluate the device, along with a team of pediatric orthopedists, physical therapists, rehabilitation medicine specialists, and orthotists.



and Rehabilitation (ROAR) Lab are developing innovative technologies to improve the quality of care and outcomes of children with cerebral palsy and other causes of impaired mobility, such as spina bifida. The researchers developed small vehicles — essentially a booster seat on a dolly, connected to a robot — which infants as young as four to six months of age can learn to move by manipulating a joystick.

The prospect of a toddler operating a robotic mobile device is intriguing, generating visions of the child moving independently around his or her home. But while the study subjects could master a joystick to move forward — with the guidance of a supervising adult, of course — Prof. Agrawal and his colleagues found they could not navigate among obstacles, such as furniture. So the team created an algorithm and rigged the robots with sensors that could detect objects nearby, transmitting slight resistance from force field joysticks to train the child to guide the robot in a different direction and avoid obstacles. The work began at the University of Delaware and now continues at Columbia.

Training physically challenged children during the toddler years could have tremendous benefits, given that the earliest years of life offer the most potential for neurological development. "We're training the brain with the help of a machine. We're hoping to apply these devices and algorithms to help mobility-impaired children," says Prof. Agrawal. "This work gives us an opportunity to extend our engineering applications to the field of medicine."

Babes Behind the Wheel

Like many parents of children with physical challenges, parents of cerebral palsy patients worry about their children's ability to be independent. Prof. Agrawal and his team in Columbia's Robotics

"Speaking" for Those Who Can't Speak

When a nonverbal child is in pain, it's usually the parent who acts as the interpreter. Does the child behave differently, or move in a different way? But being parents, they may be prone to bias. Healthcare professionals have therefore been seeking objective ways to assess pain and discomfort in nonverbal patients — such as intellectually developmentally disabled children with cerebral palsy — using self-reporting "augmentative and alternative communications" devices.

To date, self-reporting tools have included computer programs that require the user to manipulate a mouse to move a cursor to check off a small box on a screen — not the easiest task for someone with mobility challenges.

Prof. Agrawal and David P. Roye, Jr., MD, Director of Pediatric Orthopaedic Surgery at NYP/Morgan Stanley Children's and St. Giles Foundation Professor of Pediatric Orthopaedic Surgery at Columbia University College of Physicians and Surgeons, are collaborating with other members of their teams to adapt existing technologies to make it easier for nonverbal patients to report their symptoms objectively. Examples include computer tablets with large buttons or numbers on the screen corresponding to a pain scale; use of a wireless joystick to move a computer cursor; or entire sentences (such as "my head hurts" or "I have pain in my leg") which patients could "swipe" on a screen to communicate how they feel. Says



Dr. Roye, "We're not necessarily looking to create new devices, but for ways to use existing devices in new ways."

A MAGEC Approach to Treating Childhood Scoliosis (continued from page 1)

Stanley Children's Hospital and the Ana Lucia Professor of Pediatric Orthopaedic Surgery at Columbia University College of Physicians and Surgeons. MAGEC was the ideal treatment for Jeremiah, who needed leg braces and a walker to move.

Dr. Vitale implanted the MAGEC rods into Jeremiah's spine in April 2014. When he came back the following August to have the rods adjusted, Jeremiah felt very little during the procedure. NYP/Morgan Stanley Children's is the only hospital in New York City offering the MAGEC system for children with EOS.

Not Your Average Scoliosis

Scoliosis is most often diagnosed between the ages of 10 and 15. EOS develops in the first few years of life, requiring prompt and appropriate treatment to ensure that the child has adequate pulmonary function and optimal quality of life. "Early-onset scoliosis can diminish the growth of the chest and lungs and cause significant respiratory dysfunction," explains Dr. Vitale. "If the curve progresses, scoliosis can even affect life expectancy."

The MAGEC approach is an advance over conventional growing rod surgery, which requires children to return to the hospital for an additional surgical procedure every six months throughout childhood for rod lengthening. In addition to requiring general anesthesia each time, repeated surgeries increase the risk of surgical site infection and can cause psychological distress for children.

The milestone surgery builds on NYP/Morgan Stanley Children's leadership in the treatment of EOS. As head of the Pediatric Orthopaedic Society of North America task force on pediatric medical devices, Dr. Vitale visited the U.S. Food and Drug Administration (FDA) seven times over four years to advocate for the unmet needs of children with scoliosis. The FDA approved the MAGEC system on April 1, 2014. Dr. Vitale and his team developed the classification system for EOS, created a questionnaire to assess outcomes in children with the disorder, and are developing ways to reduce the risk of complications.

Children who receive growing rods progress to what Dr. Vitale calls the "Growing Rod Graduate." Research is ongoing to see if children with scoliosis who enter their teens with growing rods can live with the rods in place and avoid spinal fusion.

Children with EOS often have other medical problems that



Jeremiah with his mother, Grace, and Dr. Vitale after his growing rods were lengthened during an office procedure.

An x-ray of Jeremiah's spine, showing the MAGEC growing rods in place.

require care. For example, Jeremiah was also born with cleft lip and cleft palate and communicates via an iPad. Adds Dr. Vitale, "As a hospital with subspecialists in every field of pediatrics, we have all of the specialists a child with early-onset scoliosis may need, on the same multidisciplinary team, all in one center."

For more information about orthopedic care at NYP/Morgan Stanley Children's or to refer a patient, call (212) 305-5475.

A Dynamic Approach to Scoliosis Bracing

In September 2013, the federally funded Bracing in Adolescent Idiopathic Scoliosis Trial (BrAIST) demonstrated that wearing an external brace for 18 hours a day significantly reduced the risk of curve progression and the need for surgery in adolescents with idiopathic scoliosis, and that more hours of brace wear were associated with higher success rates. Conventional "static" braces are not effective for dynamically adjusting

the forces between the brace and the spine. David P. Roye, Jr., MD, Director of Pediatric Orthopaedic Surgery at NYP/Morgan Stanley Children's and St. Giles Foundation Professor of Pediatric Orthopaedic Surgery at Columbia University College of Physicians and Surgeons, and Sunil Agrawal, PhD, Professor of Mechanical Engineering and Rehabilitation Medicine at Columbia University, are collaborating to develop

an actively controlled brace that can dynamically adjust the forces and movements in three dimensions to control curvature in more challenging young spines. "Often the technology is there, but we don't have the bridges needed to adapt it to the clinical setting," says Dr. Roye. "Through this collaboration with the School of Engineering, we're changing that."



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