

Paper #26**Maximal Force Generated by Magnetically Controlled Growing Rods Decreases with Rod Lengthening**

Selina Poon, Hillard T. Spencer, Ronen Sever, Robert Cho

Summary: The use of magnetically controlled growing rods (MCGR) has the potential to decrease the morbidity associated with repeated surgeries, yet, strength of the lengthening mechanism as it lengthens may have an impact on the length gained with each lengthening.

We evaluated the maximal force generated by MCGR at 3 different lengthened positions and found an average decrease of 0.089 pounds per mm of additional length. This decrease may result in diminished spine length gained with each subsequent MCGR lengthening.

Hypothesis: The strength of the lengthening mechanism in the MCGRs decreases as it lengthens

Design: Laboratory mechanical testing

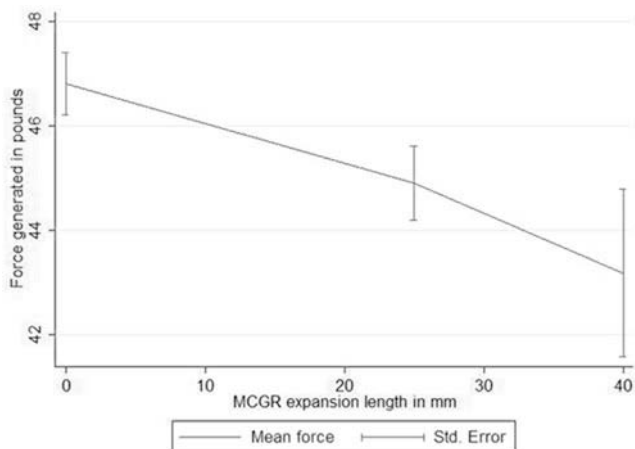
Introduction: The introduction of magnetically controlled growing rods (MCGR) has been met with great enthusiasm by surgeons managing early onset scoliosis. The new devices offer the potential to decrease the cost and morbidity associated with repeated surgeries compared to traditional growing rods. One potential negative consequence of the growing rod treatment is the law of diminishing returns, where the spine length gained decrease with each subsequent lengthening. The cause of this phenomenon is unknown and may be multifactorial. The strength of the lengthening mechanism in the MCGRs as it lengthens may have an impact on the length gained with each subsequent lengthening of the MCGR.

Objective: To evaluate the maximal force generated by MCGR at 3 different lengthened positions.

Methods: 12 MCGRs (90mm actuator length) were obtained and tested with a force testing machine to evaluate maximal force generated at different lengths. Maximal lengthening force measured in pounds of force generated by each rod was recorded at expansion length of 0mm, 25mm and 40mm. Longitudinal analysis was performed using mixed effects linear regression to account for repeated measures and variability between individual implants.

Results: At 0mm of actuator length, the mean maximum force was 46.8 lbs (SD 2.06, range 43-50). At 25mm of expansion, the mean maximum force was 44.9 lbs (SD 2.48, range 39.4-49.5). At 40mm of lengthening, the mean maximum force was 43.2 lbs (SD 5.56, range 27.3-49.1). In the mixed effects linear model, there was a statistically significant decrease in the maximal force generated with progressive MCGR length, at an average decrease of 0.089 pounds of force (95% CI, 0.030-0.148; $p=0.003$) per mm of length increase.

Conclusion: There is a small statistically significant decrease in the maximal force generated by MCGR as the rods are lengthened. This



decrease may contribute to diminished spine length gained with each subsequent MCGR lengthening.

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Paper #27**Rod lengthening with the magnetically controlled growing rod: factors influencing rod slippage and reduced gains during distractions**

Jason Pui Yin Cheung, Karen Yiu, Dino Samartzis, Kenny Kwan, James Tan, Kenneth M.C. Cheung

Summary: This is a prospective study of magnetically controlled growing rod (MCGR) patients with particular focus on the timing of rod slippage as it pertains to rod lengthening in early onset scoliosis. Findings suggest that early rod lengthening is related to older patients and reduced distance between magnets. Diminishing length gains were observed after a period of rod usage and returns to baseline after rod exchange.

Hypothesis: Early rod slippage is related to older patients and reduces the amount of achievable rod lengthening.

Design: Prospective study.

Introduction: Ability to achieve successful MCGR distraction is crucial for gradual spine lengthening. Rod slippage has been described as a failure of internal magnet rotation leading to a slippage and an inability to distract the rod. However, its onset, significance and risk factors are currently unknown. In addition, how this phenomenon pertains to actual distracted lengths is unknown. The objective of this study is to identify the factors that are associated with rod slippage and to study the pattern of achieved length gain with a standard distraction methodology.

Methods: A total of 22 patients with MCGR and at least 6 distraction episodes were prospectively studied. Patients with rod slippage occurring less than or equal to 6 distraction episodes were considered early rod slippage while those more than 6 or have yet not slipped were grouped as late rod slippage. The association of various parameters with early or late onset of rod slippage was studied. Differences between expected and achieved distraction lengths were assessed with reference to rod slippage episodes and rod exchanges to determine any patterns of diminishing returns.

Results: Patients had mean age of 7.1 years at diagnosis with mean follow-up of 49.8 months. A mean 32.4 distractions were performed per patient. Early rod slippage occurred in 14 patients and late rod slippage occurred in 8 patients. Increased height, weight, body mass index, older age, increased T1-12 and T1-S1 lengths, and less distance between magnets were significantly associated with early rod slippage. Expected distraction lengths did not translate to achieved distraction lengths and reduced gains were only observed after achieving one-third of the allowable distracted length in the MCGR. Length gains return to baseline after rod exchange.

Conclusion: Increased body habitus and reduced distance between internal magnets significantly influenced rod slippage events. Diminishing returns in distracted length gains were only observed after a period of usage.

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Paper #28**The Best Distraction Frequency for Optimizing Spine and Rod Length Gains with Magnetically Controlled Growing Rods**

Jason Cheung, Karen Yiu, Kenneth Cheung, Scott Luhmann, Charles Johnston, Peter F. Sturm, Jeff Pawelek

Summary: A study of 119 early onset scoliosis (EOS) who underwent magnetically controlled growing rod (MCGR) treatment suggests that more than 4 distractions per year yields greater rates of rod lengthening but