*Editorial*

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# The End of the Honeymoon? A Critical Reappraisal of Magnetically Controlled Growing Rods for Early-Onset Scoliosis

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## 1. Editorial

The introduction of Magnetically Controlled Growing Rods (MCGRs) was widely regarded as a paradigm shift in the management of Early Onset Scoliosis (EOS). By replacing repeated surgical lengthenings with non-invasive outpatient distractions, the technology promised to reduce the cumulative burden of surgery while preserving spinal and thoracic growth[1]. More than a decade later, however, it is legitimate to ask whether these expectations have truly been fulfilled. While MCGRs undoubtedly represented an elegant engineering solution, growing clinical evidence suggests that they have failed to overcome many of the fundamental limitations of growth-friendly surgery and, in some respects, have introduced entirely new challenges[2-9].

The greatest strength of MCGRs-the elimination of repeated surgical distractions-rapidly became their principal marketing message. Unfortunately, this message has often overshadowed a less reassuring reality. Eliminating planned procedures has not eliminated complications. Instead, scheduled operations have largely been replaced by unplanned revisions resulting from implant failure, loss of distraction, anchor pull-out, rod fracture or deep infection[2-5]. Contemporary systematic reviews report overall complication rates approaching 40% to 45%, while unplanned revision surgery remains necessary in approximately one-quarter to one-third of patients[2-4]. Consequently, the overall surgical burden for many patients has been reduced less than initially anticipated, raising the question of whether the technology has genuinely altered the natural history of growth-friendly treatment or merely shifted the timing and indication for surgery.

Perhaps the most disappointing aspect of the MCGR experience is the durability of the implant itself. Any technology designed for children undergoing years of spinal growth should be expected to function reliably over prolonged periods. Yet retrieval analyses consistently demonstrate internal locking-pin fractures, actuator wear, corrosion, O-ring failure and complete loss of distraction capability[8,9]. These findings are particularly concerning because mechanical failure is frequently occult: the external remote controller may indicate successful distraction while the implant no longer elongates[8,9]. Such silent failures undermine one of the principal advantages claimed for the technology and expose a fundamental weakness in relying on external distraction measurements without independent radiographic verification.

Equally concerning is the biological response generated by these implants. Metallosis was initially considered an isolated retrieval finding but has progressively emerged as a reproducible phenomenon across multiple clinical and retrieval series[6,8,9]. Titanium wear debris, local inflammatory reactions, pigment deposition and elevated serum titanium concentrations are now

well documented[6,8]. Although definitive evidence of systemic toxicity remains lacking, absence of evidence should not be interpreted as evidence of safety. Children with EOS represent one of the youngest populations exposed to long-term spinal instrumentation and the biological consequences of chronic metallic debris over several decades remain unknown. This uncertainty alone should encourage greater caution than has sometimes characterized clinical enthusiasm.

Another important lesson from long-term follow-up is that spinal growth cannot simply be "programmed" through periodic magnetic distractions. Progressive stiffness, spontaneous autofusion, soft-tissue contracture, implant wear and increasing construct rigidity contribute to the well-recognized phenomenon of diminishing distraction gains[5-7]. Consequently, the theoretical advantage of repeated non-invasive lengthening gradually erodes over time. In practice, the discrepancy between intended distraction and achieved spinal growth may become substantial, suggesting that mechanical elongation of the rod is not synonymous with biological growth of the spine.

Equally problematic is the quality of the evidence supporting widespread MCGR adoption. Despite more than a decade of clinical use, the literature remains dominated by retrospective case series, heterogeneous patient populations, limited follow-up and relatively small cohorts[2-7]. High-level comparative evidence is remarkably scarce, while randomized studies are entirely absent. Meta-analyses consistently conclude that MCGRs provide deformity correction and spinal growth comparable to traditional growing rods, but without convincing evidence of superior long-term clinical outcomes or lower complication rates[3,7]. Nevertheless, MCGRs were rapidly embraced by many centers worldwide before robust long-term evidence became available. This sequence-enthusiastic adoption preceding definitive evaluation-is increasingly familiar in surgical innovation and should prompt reflection within the spine community.

The regulatory history of the MAGEC system further reinforces this concern. Safety alerts issued by regulatory agencies, field safety notices, reports of end-cap separation, actuator failure, corrosion and metallosis have highlighted shortcomings that only became fully apparent after widespread clinical implementation[8,9]. These events expose an uncomfortable reality: post-market surveillance, rather than pre-market evidence, ultimately identified many of the technology's most important limitations. Such experience should encourage greater scrutiny before new implant technologies become widely adopted, particularly in vulnerable pediatric populations.

Economic arguments have also become less persuasive with time. Early analyses emphasized the avoidance of repeated surgical lengthenings and predicted substantial long-term savings[5]. Those calculations, however, assumed durable implant performance. Once revision surgery, implant exchange, prolonged follow-up, repeated imaging and management of complications are incorporated, the economic advantage becomes considerably less certain[5,7]. Cost-effectiveness, therefore, cannot be evaluated independently of implant longevity.

None of these criticisms imply that MCGRs should be abandoned. For appropriately selected patients, they remain a valuable option capable of reducing repeated anesthetic exposure and improving family convenience[1,5]. However, they should no longer be portrayed as a definitive solution to the challenges of EOS. Rather, they represent an important technological advance whose limitations have become as informative as its successes.

Perhaps the most enduring legacy of MCGRs will not be the device itself but the lesson it has taught. Innovation alone is insufficient. In pediatric spinal deformity surgery, technological elegance cannot substitute for mechanical reliability, biological safety and robust long-term evidence. The history of MCGRs reminds us that reducing the invasiveness of treatment is meaningful only if durability, safety and clinical outcomes improve in parallel. Future generations of growth-friendly implants should be judged not by the novelty of their engineering but by their capacity to deliver sustained benefits over the many years that children with EOS require treatment.

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