CROSSLINKING MAGNETIC SPINAL GROWING RODS HAS LIMITED IMPACT ON LENGTHENING: A BIOMECHANICAL ANALYSIS

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Purpose: Magnetic growing rods are a relatively new tool for the treatment of early onset scoliosis (EOS). Crosslink connectors are known to increase the stiffness and torsional rigidity of posterior spinal constructs. Supplementing constructs with crosslinks may be of particular importance in EOS because of the need to use smaller screws, especially in the proximal aspect of the construct. Crosslinks dissipate the mechanical stress so that it is shared across more anchor points. There is concern that crosslinking may limit the ability of the growing rods to lengthen. To our knowledge, there are no studies which assess the impact of crosslinks on magnetic growing rods. We hypothesized that there was no difference in the average percentage lengthened between and within magnetic growing rod constructs with and without crosslinks at varying expected lengths.

Methods: Four polyaxial 4.0mm diameter pedicle screws measuring 30mm in length were inserted proximally at the level of T5-T6 and four polyaxial 5.0mm diameter screws measuring 30mm in length were inserted distally at the level of T11-T12. 2 magnetic growing rods were secured to the pedicle screws. Three configurations underwent distraction at three distances (2.5mm, 5mm, and 7.5mm) with ten cycles each. Group 1 included the rods without crosslinks (NC); Group 2 had a proximal crosslink (PC) fixed to the rods, and Group 3 had proximal and distal crosslinks (PDC). For the PC group the crosslink was fixed at about 10mm proximal to the actuator. An additional cross clamp was added distal to the actuator about 10mm for the PDC group. During testing the spine was stabilized proximally and distally on a table. An External Remote Controller (ERC) was then centered over the two actuators and the rods were lengthened to the predetermined length set on the ERC. Prior to lengthening, a digital caliper was used to measure the distance between the adjacent pedicle screw or clamp and the lengthening open end of the actuator. The rods were then lengthened by ERC to the set amount. Another measurement was obtained and the difference of these was the actual amount distracted.

Average percentage lengthened [(amount lengthened/length set on magnet) *100] was utilized as a standardized comparison for each subset. The measurements were performed on the same model without changing the rods or any variables other than the presence of crosslinks proximally or distally at each lengthening level. Statistical comparisons were conducted with repeated measures ANOVA with Bonferroni correction using IBM SPSS Statistics 25.

Results: We found that when there are no crosslinks and the magnet is set to lengthen 2.5mm, 5mm, and 7.5mm the average percentage lengthened was 89.60+/-4.30% (95% CI, 86.53-92.69%), 91.87+/-2.89% (95% CI, 89.80-93.94%), and 93.63+/-1.53% (95% CI, 92.53-94.72%) respectively. There was no significant difference in the percentage lengthened when comparing the length subsets of the NC group (p>0.088). In the PC group, the average percentage lengthened for 2.5mm, 5mm, and 7.5mm was 71.46+/-7.49% (95% CI, 66.10-76.82%), 81.45+/-
3.99% (95% CI, 78.60-84.30%), and 89.09 +/- 2.38% (95% CI, 87.39-90.80%). This was statistically significant in all 3 subgroups (p<0.045). The PDC group had average percentage lengthened of 73.20 +/- 3.46% (95% CI, 70.73-75.68%), 85.64 +/- 3.02% (95% CI, 83.48-87.80%), and 89.49 +/- 2.13% (95% CI, 87.96-91.01%) for 2.5mm, 5mm, and 7.5mm respectively. This was also statistically significant between all 3 subgroups (p<0.020).

In assessing whether the percentage lengthened changes amongst the crosslink groups at set magnet distraction distances we found that when the constructs were expected to lengthen 2.5mm this resulted in a significant difference between the NC group and both the PC and PDC groups (p=0.000). There was no difference found between the PC and PDC group (p=1.000). At 5mm the NC, PC, and PDC groups average percent lengthened showed a significant difference between the NC group and both the PC and PDC groups (p=0.000 and 0.005, respectively). There was also no difference in the PC and PDC percent lengthened at 5mm (p=0.170). For the 7.5mm subset, we found that this lead to a significant difference between the NC and both PC and PDC groups (p=0.001). At 7.5mm lengthening, no difference was noted between PC and PDC groups (p=1.000).

**Conclusion**: In comparing the intra-construct lengthening, there is no impedance on rod lengthening when using different preset lengths on the ERC without crosslinks present. When a proximal alone or proximal and distal crosslink is present, there is a decrease in expected lengthening of around 30% at lengths of 2.5mm, 15-20% at lengths of 5mm, and 10% at 7.5mm. Despite this, lengthening is still achieved with crosslinks, with the added benefit of decreased anchor point stress. To our knowledge, this is the first study to assess the impact of crosslinking on magnetic spinal rod lengthening in a biomechanical model.