

Three-Dimensional True Spine Length of Spinal Growth Guidance Surgery and Magnetically Controlled Growing Rods for Idiopathic Early Onset Scoliosis: A Comparative Analysis

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INTRODUCTION:

Spinal Growth Guidance Surgery (SpGG) and Magnetically Controlled Growing Rods (MCGR) are techniques aimed to correct and control severe progressive spine deformity while maintaining growth. Past studies yielded comparable results between constructs using linear, vertical coronal measures, which fail to account for growth outside plane of measurement due to the 3-dimensional deformity. This study compares SpGG and MCGR outcomes in idiopathic early onset scoliosis (i-EOS) using the 3-Dimensional True Spine Length (3D-TSL), a validated method that measures spine length in 3D.

METHODS:

An international, multi-center prospective and retrospective database was queried for patients undergoing MCGR or SpGG treatment for i-EOS with two-years follow-up. 31 (20 female, 11 male) SpGG and 130 MCGR (79 female, 51 male) patients were included with routine radiographic measurements and assessment of 3D-TSL preoperatively, postoperatively, and at two-year follow-up. Mixed-model statistics, which allow for missing data points, were implemented for accurate comparative analysis, and included age group, intervention type, and visit as fixed factors with subject as random. Growth (two-year minus post-operative) was calculated with paired values only; thus the growth numbers may not equal the change in the average values for those visits.

RESULTS:

There were 161 patients (99 female) with a mean age at surgery of 8.1 years. 19.3% SpGG and 8.5% MCGR underwent repeat surgeries. Total cohort mean scoliosis decreased from 70° to 38° (46% correction; $p < 0.001$) immediately postoperative with a non-significant increase to 41° at follow-up (41% correction). By construct, MCGR reduced scoliosis postoperatively (71° to 40°, 44% correction), without significant loss of correction (+2° at 2-year visit to 42°; $p = 1.0$ vs. postoperative). SpGG initially offered better correction than MCGR ($p < .001$) from 67° preoperatively to 26° postoperatively (-41°, 61% correction, $p < .001$). However, SpGG lost some correction by the 2-year visit (+9°, 50% correction, $p = .02$ for postoperative to 2-year; $< .001$ for preoperative to 2-year) to 35°. Ultimately, the SpGG group offered better percentage correction than MCGR ($p = 0.03$).

Overall, the cohort maximal kyphosis decreased from 47° to 37° postoperatively (-10, $p < .001$) and increased to 44° at follow-up (+7, $p = .34$ for preoperative to 2-year). The maximal kyphosis for the MCGR group decreased from 49° initially to 36° postoperatively (-13°, $p < .001$), then increased to 42° at 2-year (+6, $p = .002$ postoperative vs. 2-year; $p = .04$ preoperative vs. 2-year). There was no significant difference in maximal kyphosis perioperatively for SpGG (41° preoperative to 43° postoperative); however, maximal kyphosis increased 8° by 2-year follow-up (50°, $p = .04$ between preoperative and 2-year). The changes in kyphosis were statistically different (MCGR -7 degrees vs. SpGG +9 degrees; $p < .001$).

Total cohort coronal T1-S1 height increased from 281 to 314 mm postoperatively and further increased to 336 mm at follow-up ($p < .001$ for all time points). All ages and constructs demonstrated increases in T1-S1 coronal height from preoperative to postoperative and 2-year ($p < .001$). Preoperatively, MCGR group mean height was 275 mm, which was less than the SpGG group mean height of 302 mm ($p = .01$). T1-S1 absolute height and change in height was not different between constructs postoperatively (+ 31.9, 310 mm MCGR vs. +24.4, 328 mm SpGG). T1-S1 height increased by 21.7 for the MCGR group and 24.7 mm for the SpGG group from postoperative to two-year ($p = .5$). The rate of increase in coronal height was 12.9 mm/year for MCGR and 13.8 mm/year for SpGG ($p = .8$). At follow-up, the MCGR average was 322 mm and SpGG 351 mm ($p = .1$).

In contrast to traditional T1-S1 height, 3D-TSL for SpGG and MCGR groups combined did not increase from preoperative to postoperative (338 to 342mm, $p = .8$). However, 3D-TSL increased by the 2-year visit (370mm, $p < .001$ for both constructs). All ages and constructs demonstrated growth only from preoperative and postoperative radiographs to follow-up visit ($p < .001$). MCGR and SpGG demonstrated no difference in 3D-TSL spinal heights or percentage change in height at any time. MCGR patients increased an average of 27.5mm and SpGG patients increased an average of 32.6mm postoperatively ($p = .11$). This corresponds to 14.2 mm/year for the MCGR group and 16.8 mm/year for SpGG ($p = .21$).

DISCUSSION AND CONCLUSION:

In i-EOS both constructs increased T1-S1 height from preoperative to immediately postoperative with no change in 3D-TSL. At 2-year, 3D-TSL increased for 14.2 mm/year for MCGR and 16.8 mm/year for SpGG, which was greater than the rate of increase in T1-S1 height (MCGR 12.9 mm/yr; SPGG 13.8 mm/yr). Overall, SpGG and MCGR offer similar outcomes 2-years postoperatively as assessed by 3D-TSL. SpGG had greater scoliosis percent correction and increased maximal kyphosis at 2-year follow-up. The differences in spine height change patterns demonstrated between 3D-TSL and traditional coronal height indicate that the 3D-TSL is more sensitive to deformity changes due to out-of-plane spine

growth. This emphasizes the importance of monitoring changes in spine length by using the 3D-TSL in iEOS patients, as it accounts for deformity changes that may occur over time.

