Cost analysis of a growth guidance system compared with magnetically controlled and traditional growing rods for early-onset scoliosis in the US: an integrated health care delivery system perspective

TECHNICAL APPENDIX

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Costing Analysis of Procedures

This technical appendix provides the unit costs used to estimate the total costs to the US integrated healthcare delivery system, including intraoperative neurophysiological monitoring, anesthesia, and x-ray costs, as well as all DRG, CPT and APC costs. The cumulative costs presented in Figure 1 and the results section of the main manuscript are calculated based on the total costs included in Table 3 of the main manuscript plus the key model parameters in Table 1 and Table 2 of the main manuscript. As

the bundled DRG payments include the TGR device cost, to calculate the cost of the hospital inpatient procedure alone, the TGR device costs were subtracted from the DRG payment value.

The cost of intraoperative neurophysiological monitoring CPT 95940 (Continuous intraoperative neurophysiology monitoring in the operating room, one on one monitoring requiring personal attendance) was applied to 90% (sensitivity analysis 80–100%) of the invasive procedures in the model, following the precedent in Polly et al, and clinical advice.[1] The national provider payment amount (physician payment) for CPT 95940 is $33.30 per 15 minutes, meaning that 125 minutes per invasive surgery, as per the EOS database, will cost $277.50 per patient.[2] The facility component of intraoperative neurophysiological monitoring is already included in the bundled payment amount for the surgery.

Anesthesia time for the model varied based on construct and surgery type and all values for the anesthesia provider fee amount (physician payment) have been calculated as the sum of the base units and time units, all multiplied by the conversion factor. (The facility component of anesthesia is already included in the bundled payment amount for the surgery.) The anesthesia used was CPT 00620, anesthesia for procedures on the spine and spinal cord. For this code the base units are 10, while the time units are measured in 15 minute intervals, similar to intraoperative neurophysiological monitoring, and the conversion factor is $43.63. The conversion factor was calculated using the weighted mean of the private and Medicaid patients, with respective conversion factors of $71.02 and $14.55, where the Medicaid cost was calculated as 66% of the Medicare cost.[3-5] A sensitivity analysis was performed by varying the base units between 10 and 13.

The x-ray payment (CPT 72082 Radiologic examination, spine, entire thoracic and lumbar, including skull, cervical and sacral spine if performed (e.g., scoliosis evaluation); 2 or 3 views) includes the provider amount ($62.66) and the amount paid to the facility ($100.69).

As per Polly et al[1], the TGR lengthening procedure reflected the unlisted miscellaneous surgery code 22899, whereby the reinsertion code 22849 ($1,336) was the reference procedure and was valued at 50% of the payment amount ($668) given that the TGR procedure is a lengthening and not a

reinsertion. A Growing Spine Study Group (GSSG) meeting consensus (Newport Beach, CA, January 19, 2006) was the source for the reference procedure and payment percent, whereby it was determined that this code was the best alternative to attempting to create a new CPT code for such a low-volume procedure. For MCGR lengthening, the model used the unlisted code 22899, indicating that the CPT code 95971 (electronic analysis [reprogramming] of implanted neurostimulator pulse generator system) was the reference procedure (as determined by a certified spinal coder and clinical advisors), with a value of $50.84 for the provider component in the physician office. Given that MCGR lengthenings are performed in the physician office, there is no facility component. For GGS, the CPT code 99214 (office or other outpatient visit for established patient) with a value of $108.13 was identified by clinical advisors to best describe the regular HCP visits required for GGS. (Note: at both the MCGR lengthening and the GGS HCP visit an X-ray will be required at a cost of $163.65).

Table A - 1 Insertion

Procedure	**Cost (2016 USD) (sensitivity analysis)**		
	TGR	**MCGR**	**GGS**
Arthrodesis, posterior, for spinal deformity, up to 6 vertebral segments (CPT code 22800)	1,404	1,404	1,404
Posterior segmental instrumentation, 3 to 6 vertebral segments (CPT code +22842)	801	801	801
Spinal Fusion Except Cervical W Spinal Curvature/Malignancy/Infection Or 9+ Fusions WO CC/MCC (DRG 458)	17,671[a]	17,671[a]	17,671[a]
X-ray spine, entire, survey, anteroposterior and lateral, routine (CPT code 72082)	164	164	164
Intraoperative neurophysiological monitoring (CPT code 95940)[b]	250 (222–278)	250 (222–278)	250 (222–278)
Anesthesia code 00620	1,134 (1,134–1,315)	1,134 (1,134–1,315)	1,309 (1,309–1,497)
Device construct cost[c]	15,229 (11,421–19,036)[d]	47,716 (35,787–59,645)[d]	33,456 (25,092–41,820)[d]
Calculated cost to hospital	**$36,680**	**$66,1678**	**$55,082**

[a] Calculated as the bundled DRG payment cost minus the construct device costs for TGR as described above.
[b] 90% of the cost per patient in base case, to reflect that 90% of patients will require monitoring; 80–100% in the sensitivity analysis.
[c] Full details of construct costs can be found in Table A – 8
[d] Construct sensitivity analysis ranges are ±25%
Abbreviations: CPT, current procedural terminology; DRG, diagnosis-related group; GGS, growth guidance system; MCGR, magnetically controlled growing rod; TGR, traditional growing rod; USD,

United States Dollars; WO CC/MCC, without complications/comorbidities or major complications/comorbidities.

Table A - 2 TGR lengthening

Procedure	**Cost (2016 USD) (sensitivity analysis)**			
	Outpatient	**Inpatient (1-day short stay)**	**Inpatient (standard ward)**	**Inpatient (ICU)**
Unlisted CPT code 22899 [a]	702	702	702	702
Surgery APC 0050 (facility)	2,396	2,396	NA	NA
Other musculoskeletal system and connective tissue or procedure WO CC/MCC (DRG 517)	NA	NA	10,984	NA
Other musculoskeletal system and connective tissue or procedure W CC (DRG 516)	NA	NA	NA	12,816
Pediatric intensivist (CPT 99253)	NA	NA	NA	116
X-ray spine, entire, survey, anteroposterior and lateral, routine (CPT code 72082)	164	164	164	164
Intraoperative neurophysiological monitoring (CPT code 95940)[b]	250 (222–278)	250 (222–278)	250 (222–278)	250 (222–278)
Anesthesia code 00620	785 (785–952)	785 (785–952)	785 (785–952)	785 (785–952)
Calculated cost to hospital	4,296	4,296	12,885	14,833
Percentage of patients (%)	45.8	30.1	19.1	5.0
Weighted cost to hospital (all TGR patients)	**$6,466**			

[a] Half of the reference procedure, reinsertion code 22849 ($1404) as described above.
[b] 90% of the cost per patient in base case, to reflect that 90% of patients will require monitoring; 80–100% in the sensitivity analysis.
Abbreviations: CPT, current procedural terminology; DRG, diagnosis-related group; ICU, intensive care unit; TGR, traditional growing rod; USD, United States Dollars; WO CC/MCC, without complications/comorbidities or major complications/comorbidities.

Table A - 3 Exchange

Procedure	Cost (2016 USD) (sensitivity analysis)		
	TGR	**MCGR**	**GGS**
Reinsertion of spinal fixation device (CPT code 22849)	1,404	1,404	1,404
Other musculoskeletal system and connective tissue or procedure WO CC/MCC (DRG 517)	10,984	10,984	10,984
X-ray spine, entire, survey, anteroposterior and lateral, routine (CPT code 72082)	164	164	164
Intraoperative neurophysiological monitoring (CPT code 95940)[a]	250 (222–278)	250 (222–278)	250 (222–278)
Anesthesia code 00620	785 (785–952)	785 (785–952)	785 (785–952)
Calculated cost to hospital[b]	**$13,519**	**$46,006**	**$31,746**

[a] 90% of the cost per patient in base case, to reflect that 90% of patients will require monitoring; 80–100% in the sensitivity analysis.
[b] Device cost included and reported in Table A - 8.
Abbreviations: CPT, current procedural terminology; DRG, diagnosis-related group; GGS, growth guidance system; MCGR, magnetically controlled growing rod; TGR, traditional growing rod; USD, United States Dollars; WO CC/MCC, without complications/comorbidities or major complications/comorbidities.

Table A - 4 Complete revision

Procedure	Cost (2016 USD) (sensitivity analysis)		
	TGR	**MCGR**	**GGS**
Reinsertion of spinal fixation device (CPT code 22849)	1,404	1,404	1,404
Other musculoskeletal system and connective tissue or procedure WO CC/MCC (DRG 517)	10,984	10,984	10,984
X-ray spine, entire, survey, anteroposterior and lateral, routine (CPT code 72082)	164	164	164
Intraoperative neurophysiological monitoring (CPT code 95940)[a]	250 (222–278)	250 (222–278)	250 (222–278)
Anesthesia code 00620	785 (785–952)	785 (785–952)	785 (785–952)
Calculated cost to hospital[b]	**$13,519**	**$46,007**	**$31,746**

[a] 90% of the cost per patient in base case, to reflect that 90% of patients will require monitoring; 80–100% in the sensitivity analysis.
[b] Device cost included and reported in Table A - 8.
Abbreviations: CPT, current procedural terminology; DRG, diagnosis-related group; GGS, growth guidance system; MCGR, magnetically controlled growing rod; TGR, traditional growing rod; USD, United States Dollars; WO CC/MCC, without complications/comorbidities or major complications/comorbidities.

Table A - 5 Partial revision

Procedure	Cost (2016 USD) (sensitivity analysis)		
	TGR	**MCGR**	**GGS**
Reinsertion of spinal fixation device (CPT code 22849)	1,404	1,404	1,404
Other musculoskeletal system and connective tissue or procedure WO CC/MCC (DRG 517)	10,984	10,984	10,984
X-ray spine, entire, survey, anteroposterior and lateral, routine (CPT code 72082)	164	164	164
Intraoperative neurophysiological monitoring (CPT code 95940)[a]	250 (222–278)	250 (222–278)	250 (222–278)
Anesthesia code 00620	785 (785–952)	785 (785–952)	785 (785–952)
Calculated cost to hospital[b]	**$30,503**	**$44,763**	**$31,746**

[a] 90% of the cost per patient in base case, to reflect that 90% of patients will require monitoring; 80–100% in the sensitivity analysis.
[b] Calculated as the total cost of complete revision, minus the parts that do not require replacement, as described in the main manuscript.
Abbreviations: CPT, current procedural terminology; DRG, diagnosis-related group; GGS, growth guidance system; MCGR, magnetically controlled growing rod; TGR, traditional growing rod; USD, United States Dollars; WO CC/MCC, without complications/comorbidities or major complications/comorbidities.

Table A - 6 Deep infection

Procedure	Cost (2016 USD) (sensitivity analysis)		
	TGR	**MCGR**	**GGS**
Reinsertion of spinal fixation device (CPT code 22849)	1,404	1,404	1,404
Other musculoskeletal system and connective tissue or procedure WO CC/MCC (DRG 517)	10,984	10,984	10,984
IV Clindamycin 4 weeks	0[a]	0[a]	0[a]
X-ray spine, entire, survey, anteroposterior and lateral, routine (CPT code 72082)	164	164	164
Intraoperative neurophysiological monitoring (CPT code 95940)[b]	250 (222–278)	250 (222–278)	250 (222–278)
Anesthesia code 00620	785 (785–952)	785 (785–952)	785 (785–952)
Calculated cost to hospital[c]	**$13,519**	**$46,007**	**$31,746**

[a] Cost of IV antibiotics already included in DRG 517.
[b] 90% of the cost per patient in base case, to reflect that 90% of patients will require and have monitoring; 80–100% in the sensitivity analysis.
[c] Device cost included and reported in Table A – 8.
Abbreviations: CPT, current procedural terminology; DRG, diagnosis-related group; GGS, growth guidance system; MCGR, magnetically controlled growing rod; TGR, traditional growing rod; USD, United States Dollars; WO CC/MCC, without complications/comorbidities or major complications/comorbidities.

Table A- 7 Removal and final fusion

Procedure		**TGR**	**MCGR**	**GGS**
Arthrodesis, posterior, for spinal deformity, up to 6 vertebral segments (CPT code 22800)[a]	% of patients	5%	5%	5%
	unit cost	1,404	1,404	1,404
Arthrodesis, posterior, for spinal deformity, 7 to 12 vertebral segments (CPT code 22802) [a]	% of patients	75%	75%	75%
	unit cost	2,181	2,181	2,181
Arthrodesis, posterior, for spinal deformity, 13 or more vertebral segments (CPT code 22804)[a]	% of patients	20%	20%	20%
	unit cost	2,522	2,522	2,522
Posterior segmental instrumentation, 3 to 6 vertebral segments (CPT code +22842)[a]	% of patients	5%	5%	5%
	unit cost	801	801	801
Posterior segmental instrumentation, 7 to 12 vertebral segments (CPT code +22843)[a]	% of patients	75%	75%	75%
	unit cost	856	856	856
Posterior segmental instrumentation, 13 or more vertebral segments (CPT code +22844)[a]	% of patients	20%	20%	20%
	unit cost	1,030	1,030	1,030
Osteotomy of spine, posterior or posterolateral approach, 1 vertebral segment, thoracic (CPT code 22212)[a]	% of patients	12%[b]	12% [b]	35% [b]
	unit cost	1,537	1,537	1,537
Osteotomy of spine, posterior or posterolateral approach, 1 vertebral segment, lumbar (CPT code 22214)[a]	% of patients	12% [b]	12% [b]	35% [b]
	unit cost	1,543	1,543	1,543
Osteotomy of spine, posterior or posterolateral approach, each additional vertebral segment (CPT code +22216)[a]	% of patients	48%[c]	48%[c]	140%[c]
	unit cost	380	380	380
Spinal Fusion Except Cervical W Spinal Curvature/Malignancy/Infection or 9+ Fusions WO CC/MCC (DRG 458)[a]	% of patients	100%	100%	100%
	unit cost	32,900	32,900	32,900
X-ray spine, entire, survey, anteroposterior and lateral, routine (CPT code 72082)		164	164	164
Intraoperative neurophysiological monitoring (CPT code 95940)[d]		250 (222–278)	250 (222–278)	250 (222–278)
Anesthesia code 00620		1,309 (1,309–1,497)	1,309 (1,309–1,497)	1,309 (1,309–1,497)
Calculated cost to hospital		**$38,272.03**	**$38,272.03**	**$39,329.74**

[a] Cost due to each CPT/DRG code is calculated as the percentage of patients that require procedure, multiplied by the unit cost of the procedure.
[b] 24% of patients with TGR and MCGR are assumed to have an osteotomy, with a 1:1 thoracic/lumbar split, while 70% of patients with GGS are assumed to have an osteotomy, with a 1:1 thoracic/lumbar split.
[c] Each patient with an osteotomy is assumed to require two additional vertebral segments.
[d] 90% of the cost per patient in base case, to reflect that 90% of patients will require monitoring; 80–100% in the sensitivity analysis.
Abbreviations: CPT, current procedural terminology; DRG, diagnosis-related group; GGS, growth

guidance system; MCGR, magnetically controlled growing rod; TGR, traditional growing rod; USD, United States Dollars; WO CC/MCC, without complications/comorbidities or major complications/comorbidities.

Table A- 8 Device costs (2016 USD)

TGR components	**Cost (sensitivity analysis)**
Set screw	1,752
Pedicle screw	10,405
Wedding band	625
Tandem connector	1250
Cross links	650
Dual rod	1,500
Total device costs[a]	**15,229 (11,421–19,036)**
MCGR components	
Set screw	1,752
Pedicle screw	10,405
Cross links	650
Dual rod	35, 000
Total device costs[a]	**47,716 (35,787–59,645)**
GGS components	
Set screw	1,172
GGS set screw	3,040
Multiaxial screws	24,722
Cross links	2,200
Dual rod	2,322
Total device costs[a]	**33,456 (25,092–41,820)**

[a] Factoring in percentage of patients that require each component (as described in main manuscript).
Abbreviations: GGS, growth guidance system; MCGR, magnetically controlled growing rod; TGR, traditional growing rod; USD, United States Dollars

References

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