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Review Article

The 100 Most Cited Articles in Early Onset Scoliosis: A Bibliometric Analysis

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Abstract

Purpose: Early onset scoliosis is the onset of scoliosis in children, under the age of 10, irrespective of aetiology. There is a role for both conservative and surgical treatment. The purpose of this study was to identify the 100 most cited articles relating to early onset scoliosis. This is the first bibliometric analysis

Methods: The Dimensions database was utilised to search for a selection of keywords related to early onset scoliosis. The 100 most highly cited articles were selected from high impact journals and several attributes including number of citations, year of publication and publishing journals were analysed

Results: The highest cited article was cited 569 times whilst the lowest cited 44 times. The articles were published from 1954 to 2020 with the majority being published after 2000. The leading journal for publication of these articles was the Journal of Paediatric Orthopaedics with 23 articles, followed by Spine with 22. The articles, corresponding authors and number of citations are demonstrated in Table 1.

Conclusions: Our study is a bibliometric analysis of the 100 most cited articles in early onset scoliosis and demonstrates the key scientific contributions to this area of spinal surgery.

***Keywords:** Bibliographic review; Early onset; Scoliosis*

Introduction

The definition for early onset scoliosis, "scoliosis with onset less than the age of 10 years, regardless of aetiology" was agreed recently, although the concept itself consolidates Ponsetti's work from the 1950s [1]. The aetiology of patients with EOS may include those of an idiopathic nature, have an underlying syndrome or a neuromuscular condition. The spinal deformity of EOS corresponds to a critical period of lung development as well as a crucial development of the spine with an increase in the length of T1 to S1 segment of 10 cm in the first 5 years of life, followed by 5 cm in the successive 5 years [2].

The natural history of EOS is associated with significant morbidity including respiratory insufficiency, cor pulmonale as well as a high mortality. The treatment of EOS can vary from observation (over 90% of idiopathic scoliosis resolves spontaneously) to surgery [3]. Surgery can include distraction based, guided growth and compression-based strategies. [2]

A citation analysis evaluates an article on the number of citations received and is a surrogate measure of the impact factor of the article [4]

The purpose of our study was to evaluate the 100 most cited articles in early onset scoliosis and to further assess several of the article's attributes.

Methods

The citation search was carried out using the Dimensions database in February 2024. The keywords utilised were "early onset" and "scoliosis". The search terms were limited to the English language. The title and abstract were analysed by 2 authors and those results not relevant to the search were discarded.

Those citations which matched the search criteria were included and further analysed according to number of criteria including citations, first author, journal, year of publication and country.

Results

The 100 most cited articles are included in supplement 1. Out of 100 most cited top 20 are included in Table 1. The top 100 were published from the years 1954 to 2020. Table 2 includes number of publications in each decade. The article with the highest citation count was cited on 569 instances whilst the 100th cited article was cited on 44 instances. The top cited articles were published in 20 different journals with the greatest number published in the following journals, Journal of Paediatric Orthopaedics, Spine, Journal of Bone and Joint Surgery, Clinical Orthopaedics and Related Research and the European Spine Journal, (Table 3)

Vast majority of the papers (93%) were of levels of evidence 4 and 5. This can be reviewed in table 4

Table 1. 100 top cited papers in early onset scoliosis.

Rank	Authors	Title	Citations	Level of evidence
1	Akbarnia, Behrooz A	Dual Growing Rod Technique for the Treatment of Progressive Early-Onset Scoliosis	569	4
2	Bess, Shay	Complications of Growing-Rod Treatment for Early-Onset Scoliosis	507	3
3	Akbarnia, Behrooz A	Dual Growing Rod Technique Followed for Three to Eleven Years Until Final Fusion	330	3
4	Sankar, Wudbhav N	Lengthening of Dual Growing Rods and the Law of Diminishing Returns	278	4
5	Thompson, George H	Growing Rod Techniques in Early-Onset Scoliosis	243	3
6	Williams, Brendan A	Development and Initial Validation of the Classification of Early-Onset Scoliosis (C-EOS)	236	5
7	Emans, John B	The Treatment of Spine and Chest Wall Deformities With Fused Ribs by Expansion Thoracostomy and Insertion of Vertical Expandable Prosthetic Titanium Rib	218	4
8	Akbarnia, Behrooz A	Next Generation of Growth-Sparing Techniques	201	4

9	James, J. I. P.	Idiopathic scoliosis; the prognosis, diagnosis, and operative indications related to curve patterns and the age at onset.	200	5
10	Branthwaite, M.A.	Cardiorespiratory consequences of unfused idiopathic scoliosis	188	4
11	Sankar, Wudbhav N	Comparison of Complications Among Growing Spinal Implants	161	2
12	Mackenzie, W.G. Stuart	Surgical Site Infection Following Spinal Instrumentation for Scoliosis	159	2b
13	Dannawi, Z	Early results of a remotely-operated magnetic growth rod in early-onset scoliosis.	156	4
14	Akbarnia, Behrooz A	Complications of Growth-Sparing Surgery in Early Onset Scoliosis	156	5
15	Akbarnia, Behrooz A	Traditional Growing Rods Versus Magnetically Controlled Growing Rods for the Surgical Treatment of Early-Onset Scoliosis: A Case-Matched 2-Year Study	144	2
16	Yang, Scott	Early-Onset Scoliosis: A Review of History, Current Treatment, and Future Directions	138	5
17	Flynn, John M	Growing-Rod Graduates	123	4
18	Hickey, B. A.	Early experience of MAGEC magnetic growing rods in the treatment of early onset scoliosis	119	4
19	Akbarnia, Behrooz A	Management Themes in Early Onset Scoliosis	118	5
20	Choi, Edmund	Implant Complications After Magnetically Controlled Growing Rods for Early Onset Scoliosis	117	4
21	Fletcher, Nicholas D	Serial Casting as a Delay Tactic in the Treatment of Moderate-to-Severe Early-onset Scoliosis	116	4
22	Yang, Justin S	Growing Rods for Spinal Deformity: Characterizing Consensus and Variation in Current Use	111	5
23	McCarthy, Richard E	The Shilla Growth Guidance Technique for Early-Onset Spinal Deformities at 2-Year Follow-Up	111	4
24	Thakar, Chrishan	Systematic review of the complications associated with magnetically controlled growing rods for the treatment of early onset scoliosis	108	3
25	Karol, Lori A	Early Definitive Spinal Fusion in Young Children: What We Have Learned	107	4
26	Muirhead, A	The assessment of lung function in children with scoliosis.	106	4
27	Gillingham, Bruce L	Early onset idiopathic scoliosis.	105	4
28	Elsebai, Hazeem B	Safety and Efficacy of Growing Rod Technique for Pediatric Congenital Spinal Deformities	102	4
29	Kabirian, Nima	Deep Surgical Site Infection Following 2344 Growing-Rod Procedures for Early-Onset Scoliosis	101	4
30	Mineiro, Jorge	Subcutaneous Rodding for Progressive Spinal Curvatures: Early Results	99	4

31	El-Hawary, Ron	Early Onset Scoliosis - Time for Consensus	98	5
32	Skaggs, David L	Early Onset Scoliosis Consensus Statement, SRS Growing Spine Committee, 2015	98	5
33	Tis, John E.	Early Onset Scoliosis	95	5
34	Hasler, Carol-Claudius	Efficacy and safety of VEPTR instrumentation for progressive spine deformities in young children without rib fusions	94	4
35	Watanabe, Kota	Risk Factors for Complications Associated With Growing-Rod Surgery for Early-Onset Scoliosis	94	4
36	Teoh, Kar H	Do magnetic growing rods have lower complication rates compared with conventional growing rods?	92	3
37	Sucato, Daniel J	Management of Severe Spinal Deformity	91	4
38	Campbell, Robert M	Spine Deformities in Rare Congenital Syndromes	88	4
39	Cunin, V.	Early-onset scoliosis – Current treatment	87	4
40	Lebon, Julie	Magnetically controlled growing rod in early onset scoliosis: a 30-case multicenter study	87	4
41	Teoh, Kar Hao	Magnetic controlled growing rods for early-onset scoliosis: a 4 -year follow-up	86	4
42	D'Astous, Jacques L	Casting and Traction Treatment Methods for Scoliosis	83	4
43	Fernandes, Ped-ro	Natural History of Early Onset Scoliosis	83	4
44	Ouellet, Jean	Surgical Technique: Modern Luqué Trolley, a Self-growing Rod Technique	83	4
45	McCarthy, Rich-ard E	Shilla Growing Rods in a Caprine Animal Model: A Pilot Study	83	4
46	Hosseini, Pooria	Magnetically controlled Growing Rods for Early-onset Scolio-sis	82	3
47	McCarthy, Rich-ard E	Shilla Growth Guidance for Early-Onset Scoliosis	82	4
48	Baulesh, David M	The Role of Serial Casting in Early-onset Scoliosis (EOS)	78	3
49	Corona, Jacquel-ine	Measuring Quality of Life in Children With Early OnsetScolio-sis	77	2
50	Akbarnia, Beh-rooz A	Innovation in Growing Rod Technique	75	3
51	Motoyama, Etsu-ro K	Thoracic malformation with early-onset scoliosis: Effect of serial VEPTR expansion thoracoplasty on lung growth and function in children	75	4
52	Jain, Amit	Avoidance of “Final” Surgical Fusion After Growing-Rod Treat-ment for Early-Onset Scoliosis	74	3
53	Schroerlucke, Samuel R	How Does Thoracic Kyphosis Affect Patient Outcomes in Growing Rod Surgery?	74	3
54	Ridderbusch, Karsten	Preliminary Results of Magnetically Controlled Growing Rods for Early Onset Scoliosis	72	4

55	Mahar, Andrew Todd	Biomechanical comparison of different anchors (foundations) for the pediatric dual growing rod technique	72	4
56	Smith, John T	A New Classification System to Report Complications in Growing Spine Surgery	72	3
57	Rodillo, E	Scoliosis in Spinal Muscular Atrophy: Review of 63 Cases	71	4
58	Matsumoto, Hiroko	The Final 24-Item Early Onset Scoliosis Questionnaires (EOSQ-24)	70	2
59	Vitale, Michael G	Variability of Expert Opinion in Treatment of Early-onset Scoliosis	69	5
60	La Rosa, Guido	Magnetically Controlled Growing Rods for the Management of Early-onset Scoliosis	66	4
61	Watanabe, Kota	Risk Factors for Proximal Junctional Kyphosis Associated With Dual-rod Growing-rod Surgery for Early-onset Scoliosis	65	4
62	Teoh, K H	Metallosis following implantation of magnetically controlled growing rods in the treatment of scoliosis: a case series.	65	4
63	Fletcher, Nicholas D	Early onset scoliosis: current concepts and controversies	64	4
64	Doany, Michael E	Health-Related Quality of Life in Early-Onset Scoliosis Patients Treated Surgically	63	3
65	Noordeen, Hilali M	In Vivo Distraction Force and Length Measurements of Growing Rods	63	4
66	Cheung, Jason Pui Yin	Special Article: Update on the Magnetically Controlled Growing Rod: Tips and Pitfalls	63	5
67	Wang, Shengru	Dual Growing Rods Technique for Congenital Scoliosis	63	4
68	Redding, Gregory J	Structure-Respiration Function Relationships Before and After Surgical Treatment of Early-onset Scoliosis	62	4
69	Thompson, W	The use of magnetically-controlled growing rods to treat children with early-onset scoliosis: early radiological results in 19 children.	62	4
70	Cheung, Jason Pui Yin	Mean 6-Year Follow-up of Magnetically Controlled Growing Rod Patients With Early Onset Scoliosis: A Glimpse of What Happens to Graduates.	62	4
71	Yoon, Wai Weng	Improvement of Pulmonary Function in Children With Early-Onset Scoliosis Using Magnetic Growth Rods	61	4
72	Rolton, Daniel	Magnetic controlled growth rods versus conventional growing rod systems in the treatment of early onset scoliosis: a cost comparison	60	4
73	Joyce, Thomas	Analysis of Explanted Magnetically Controlled Growing Rods From Seven UK Spinal Centers	60	4
74	Karol, Lori A	The Natural History of Early-onset Scoliosis	59	4
75	Gomez, Jaime A	"Growth friendly" spine surgery: management options for the young child with scoliosis.	58	4

76	Andras, Lindsay M.	Growing Rods Versus Shilla Growth Guidance: Better Cobb Angle Correction and T1–S1 Length Increase But More Surgeries	58	3
77	Shah, Suken A	The Effect of Serial Growing Rod Lengthening on the Sagittal Profile and Pelvic Parameters in Early-Onset Scoliosis	57	4
78	BYLUND, PER	Muscle Fiber Types in Thoracic Erector Spinae Muscles Fiber Types in Idiopathic and Other Forms of Scoliosis	57	2
79	Phillips, Jonathan H	Mortality and Morbidity in Early-Onset Scoliosis Surgery	56	4
80	Demirkiran, Halil G	Serial Derotational Casting in Congenital Scoliosis as a Time-buying Strategy	56	4
81	Sankar, Wudbhav N	Neurologic Risk in Growing Rod Spine Surgery in Early Onset Scoliosis	55	4
82	Waldron, Sean R	Early Onset Scoliosis	54	4
83	Matsumoto, Hiroko	Psychosocial Effects of Repetitive Surgeries in Children With Early-Onset Scoliosis	53	3
84	Flynn, John M	Psychological Dysfunction in Children Who Require Repetitive Surgery for Early Onset Scoliosis	53	3
85	Charroin, C.	Direct costs associated with the management of progressive early onset scoliosis: Estimations based on gold standard technique or with magnetically controlled growing rods	52	4
86	Dede, Ozgur	Pulmonary and Radiographic Outcomes of VEPTR (Vertical Expandable Prosthetic Titanium Rib) Treatment in Early-Onset Scoliosis	51	4
87	Olgun, Z. Deniz	Vertebral Body Growth During Growing Rod Instrumentation	51	4
88	Ahmad, A	Quantifying the 'law of diminishing returns' in magnetically controlled growing rods.	50	4
89	Ramirez, Norman	The Vertical Expandable Prosthetic Titanium Rib in the treatment of spinal deformity due to progressive early onset scoliosis	49	4
90	Keskinen, Heli	Preliminary comparison of primary and conversion surgery with magnetically controlled growing rods in children with early onset scoliosis	49	3
91	Poe-Kochert, Connie	Final Fusion After Growing-Rod Treatment for Early Onset Scoliosis	49	4
92	Zhang, Yan-Bin	Treatment of early-onset scoliosis: techniques, indications, and complications	49	5
93	El-Hawary, Ron	What is the Risk of Developing Proximal Junctional Kyphosis During Growth Friendly Treatments for Early-onset Scoliosis?	48	3
94	Stokes, Oliver M	Reducing radiation exposure in early-onset scoliosis surgery patients: novel use of ultrasonography to measure lengthening in magnetically-controlled growing rods	48	2

95	Brooks, Jaysson T	What's New in the Management of Neuromuscular Scoliosis	48	4
96	White, Klane K	VEPTR™ Growing Rods for Early-onset Neuromuscular Scoliosis: Feasible and Effective	48	4
97	Mesfin, Addisu	Spinal Muscular Atrophy: Manifestations and Management	47	4
98	Emans, John B	Prediction of Thoracic Dimensions and Spine Length Based on Individual Pelvic Dimensions in Children and Adolescents	47	4
99	Smith, John T	Bilateral Rib-to-pelvis Technique for Managing Early-onset Scoliosis	45	4
100	Thompson, George H	Does Vancomycin Powder Decrease Surgical Site Infections in Growing Spine Surgery?	44	3

Table 2. Number of Publications in each decade.

Decade of Publication	Number of articles
Pre 1990	5
1990-1999	0
2000-2009	15
2010-2019	79
2020-2024	1

Table 3. Number of Publications according to journal published.

Journal Name	Number
Journal of Paediatric Orthopaedics	23
Spine	22
JBJS	12
CORR	8
European Spinal Journal	6
The Bone & Joint Journal	6
Spine Deformity	4
The Spine Journal	4
Journal of American Academy Surgeons	3
Orthopaedics & Traumatology Surgery & Research	2
Chinese Medical Journal	1
Clinical Spinal Surgery	1
Current Reviews in Musculoskeletal Medicine	1
Journal of Child Neurology	1
Journal of Orthopaedic Surgery	1
Neurosurgery	1
Orthopedic Clinics of North America	1
Paediatric Respiratory Reviews	1
Pediatrics	1
Respiratory Medicine	1

Table 4. Showing level of evidence.

Level of evidence	Number of studies
2	7
3	18
4	63
5	12

Discussion

The study identifies the 100 most cited articles in early onset scoliosis and highlights those features which may make an article more likely to be cited as well as the journals in which it is most likely to be published.

Akbarnia et al had the most cited paper, a case review of 23 patients that had dual growing rod surgery, demonstrating an improvement in average scoliosis from 82 degrees to 36 degrees at the final follow up. The paper was a first report of a dual growing rod technique with a follow up of greater than 2 years (range 2-9.25 years). The technique demonstrated less implant and alignment complications (1 developed crankshaft phenomenon and 1 developed junctional kyphosis requiring construct extension) compared to single rod techniques.

The second most cited article was by Bess et al. This described the complications of the growing rod technique, utilising a multicentre database. 140 patients were included, undergoing a total 897 procedures, with a mean follow up of 5 years. 81 patients (58%) had at least 1 complication. There was less implant complications associated with dual rod implantation than single rod implantation (10% vs 27%). The risk of wound complications, prominent implants and unplanned surgery was greater in subcutaneous dual rod placement than submuscular dual rods

The third most cited paper was from Akbarnia et al. The purpose of the study was to identify factors which affect the outcome of dual growing rod treatment, namely the timing of the lengthening as well as the as well as the effect of the frequency of the lengthening until final fusion.

The study identified patients with non-congenital scoliosis from the multicentre and multinational Growing Spine Study Group database with a minimum of 2 years follow up. The study demonstrated an improvement in Cobb angle from 81 degrees to 27.7 after the final fusion. Although the outcomes demonstrated an improvement in T1-S1 growth and curve correction, in those corrected more frequently, this is offset by the increased number of surgery as well as the concomitant complications in almost half of the patients.

Sankar et al had the 4th most cited paper. This was a case review of 38 patients undergoing dual growing rods from 5 different centres with a mean follow up of 5.7 years. The study described the phenomenon of "diminishing returns" with repeated surgical lengthening's. At the time of implantation, the average T1-S1gain was an average 1.76+/-0.71 cm/ year. This reduced to 0.41 ± 0.58 cm at the time of the 7th lengthening.

The 5th most cited paper was written by Thompson et al. This was a descriptive multicentre study of growing rod techniques evaluating surgical strategies including single rod technique, dual rod techniques and vertical expandable prosthetic rib (VEPTR). The rod techniques were subdivided into single growing rod with a short anterior/ posterior apical fusion (group 1), a single growing rod (group 2) and dual growing rods (group 3). Average preoperative scoliosis was 85 degrees in group 1, 61 degrees in group 2, and 92 degrees in group 3. Following definitive fusion, the mean postoperative scoliosis was 65, 39, and 26 degrees, respectively.

The VEPTR was also subcategorised according to the type of construct from unilateral rib to spine hybrid, bilateral rib to spine hybrid, unilateral rib to pelvis and bilateral rib to pelvis hybrid. The average curve was 77 degrees preoperatively to 39 degrees at final follow up.

The theme of the first 5 papers reflects that of the 100 most cited papers, namely the papers are mainly descriptive studies of outcomes or surgical techniques. Many of the studies are levels of evidence 3 (18%) or 4 (63%) which can be partly explained by the limited numbers of patients that undergo surgery, and thus larger studies may not be feasible. Other bibliometric analyses in spinal surgery have reported similar findings [5]

The limitations of bibliometric studies include that earlier studies may be overly represented whilst the practice of self-citation may also artificially inflate the number of citations. The exclusion of non-English language studies may also limit the citation of valuable research in other languages.

Conclusions

This is an article which offers an important perspective on the study of early onset scoliosis, via citation analysis. Our study is the first bibliometric analysis of the 100 most cited articles in early onset scoliosis and demonstrates the key scientific contributions to this area of spinal surgery.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. El-Hawary, R., et al(2015). Early onset scoliosis—Time for consensus. *Spine Deformity*, *3*(2), 105–106. https://doi.org/10.1016/j.jspd.2015.01.003
2. Yang, S et al (2016). Early-onset scoliosis: A review of history, current treatment, and future directions. *Pediatrics*, *137*(1), e20150709. https://doi.org/10.1542/peds.2015-0709
3. Thompson, S. et al (1980). Prognosis in infantile idiopathic scoliosis. *The Journal of Bone and Joint Surgery. British Volume*, *62-B*(2), 151–154. https://doi.org/10.1302/0301-620X.62B2.7364824
4. Lee, Y. C.et al (2017). Most cited publications in cervical spine surgery. *International Journal of Spine Surgery*, *11*(3), 19. https://doi.org/10.14444/4019
5. Baeesa, S. S., et al (2017). Quality of spine surgery research from the arab countries: A systematic review and bibliometric analysis. *BioMed Research International*, *2017*, 1–5. https://doi.org/10.1155/2017/7560236
6. Akbarnia, B. A., et al (2005). Dual growing rod technique for the treatment of progressive early-onset scoliosis: A multicenter study. *Spine*, *30*(Supplement), S46–S57. https://doi.org/10.1097/01.brs.0000175190.08134.73
7. Bess, S., et al (2010). Complications of growing-rod treatment for early-onset scoliosis: Analysis of one hundred and forty patients. *The Journal of Bone and Joint Surgery-American Volume*, *92*(15), 2533–2543. https://doi.org/10.2106/JBJS.I.01471
8. Akbarnia, B. A et al (2008). Dual growing rod technique followed for three to eleven years until final fusion: The effect of frequency of lengthening. *Spine*, *33*(9), 984–990. https://doi.org/10.1097/BRS.0b013e31816c8b4e
9. Sankar, W. N. et al (2011). Lengthening of dual growing rods and the law of diminishing returns: *Spine*, *36*(10), 806–809. https://doi.org/10.1097/BRS.0b013e318214d78f
10. Thompson, G. H et al 2007). Growing rod techniques in early-onset scoliosis. *Journal of Pediatric Orthopaedics*, *27* (3), 354–361. https://doi.org/10.1097/BPO.0b013e3180333eea
11. Williams, B. A., et al (2014). Development and initial validation of the classification of early-onset scoliosis(C-eos). *Journal of Bone and Joint Surgery*, *96*(16), 1359–1367. https://doi.org/10.2106/JBJS.M.00253
12. Emans, J. B., et al (2005). The treatment of spine and chest wall deformities with fused ribs by expansion thoracostomy and insertion of vertical expandable prosthetic titanium rib: Growth of thoracic spine and improvement of lung volumes. *Spine*, *30*(Supplement), S58–S68. https://doi.org/10.1097/01.brs.0000175194.31986.2f
13. Akbarnia, B. A. et al (2013). Next generation of growth-sparing techniques: Preliminary clinical results of a magnetically controlled growing rod in 14 patients with early-onset scoliosis. *Spine*, *38*(8), 665–670. https://doi.org/10.1097/BRS.0b013e3182773560

14. James, J. I. P. (1954). IDIOPATHIC SCOLIOSIS: The prognosis, diagnosis, and operative indications related to curve patterns and the age at onset. *The Journal of Bone and Joint Surgery. British Volume*, *36-B*(1), 36–49. https://doi.org/10.1302/0301-620X.36B1.36

15. Branthwaite, M. A. (1986). Cardiorespiratory consequences of unfused idiopathic scoliosis. *British Journal of Diseases of the Chest*, *80*, 360–369. https://doi.org/10.1016/0007-0971(86)90089-6

16. Sankar, W. N. et al (2010). Comparison of complications among growing spinal implants: *Spine*, *35*(23), 2091–2096. https://doi.org/10.1097/BRS.0b013e3181c6edd7

17. Mackenzie, W. G. S., et al (2013). Surgical site infection following spinal instrumentation for scoliosis: A multicenter analysis of rates, risk factors, and pathogens. *Journal of Bone and Joint Surgery*, *95*(9), 800–806. https://doi.org/10.2106/JBJS.L.00010

18. Dannawi, Z., et al (2013). Early results of a remotely-operated magnetic growth rod in early-onset scoliosis. *The Bone & Joint Journal*, *95-B*(1), 75–80. https://doi.org/10.1302/0301-620X.95B1.29565

19. Akbarnia, B. A et al (2010). Complications of growth-sparing surgery in early onset scoliosis: *Spine*, *35*(25), 2193–2204. https://doi.org/10.1097/BRS.0b013e3181f070b5

20. Akbarnia, B. A., et al (2014). Traditional growing rods versus magnetically controlled growing rods for the surgical treatment of early-onset scoliosis: A case-matched 2-year study. *Spine Deformity*, *2*(6), 493–497. https://doi.org/10.1016/j.jspd.2014.09.050

21. Flynn, J. M et al. (2013). Growing-rod graduates: Lessons learned from ninety-nine patients who completed lengthening. *Journal of Bone and Joint Surgery*, *95*(19), 1745–1750. https://doi.org/10.2106/JBJS.L.01386

22. Hickey, B. A. et al (2014). Early experience of MAGEC magnetic growing rods in the treatment of early onset scoliosis. *European Spine Journal*, *23*(S1), 61–65. https://doi.org/10.1007/s00586-013-3163-0

23. Akbarnia, B. A. (2007). Management themes in early onset scoliosis. *Journal of Bone and Joint Surgery*, *89*(suppl_1), 42–54. https://doi.org/10.2106/JBJS.F.01256

24. Choi, E., et al (2017). Implant complications after magnetically controlled growing rods for early onset scoliosis: A multicenter retrospective review. *Journal of Pediatric Orthopaedics*, *37*(8), e588–e592. https://doi.org/10.1097/BPO.0000000000000803

25. Fletcher, N. D., et al (2012). Serial casting as a delay tactic in the treatment of moderate-to-severe early-onset scoliosis. *Journal of Pediatric Orthopaedics*, *32*(7), 664–671. https://doi.org/10.1097/BPO.0b013e31824bdb55

26. Yang, J. S., et al 2010). Growing rods for spinal deformity: Characterizing consensus and variation in current use. *Journal of Pediatric Orthopaedics*, *30*(3), 264–270. https://doi.org/10.1097/BPO.0b013e3181d40f94

27. McCarthy, R. E., et al (2014). The shilla growth guidance technique for early-onset spinal deformities at 2-year follow-up: A preliminary report. *Journal of Pediatric Orthopaedics*, *34*(1), 1–7. https://doi.org/10.1097/BPO.0b013e31829f92dc

28. Thakar, C., et al (2018). Systematic review of the complications associated with magnetically controlled growing rods for the treatment of early onset scoliosis. *European Spine Journal*, *27*(9), 2062–2071. https://doi.org/10.1007/s00586-018-5590-4

29. Karol, L. A. (2011). Early definitive spinal fusion in young children: What we have learned. *Clinical Orthopaedics & Related Research*, *469*(5), 1323–1329. https://doi.org/10.1007/s11999-010-1622-z

30. Muirhead, A., et al 1985). The assessment of lung function in children with scoliosis. *The Journal of Bone and Joint Surgery. British Volume*, *67-B*(5), 699–702. https://doi.org/10.1302/0301-620X.67B5.4055863

31. Gillingham, B. L., et al (2006). Early onset idiopathic scoliosis: *Journal of the American Academy of Orthopaedic Surgeons*, *14*(2), 101–112. https://doi.org/10.5435/00124635-200602000-00005

32. Elsebai, H. B., et al (2011). Safety and efficacy of growing rod technique for pediatric congenital spinal deformities. *Journal of Pediatric Orthopaedics*, *31*(1), 1–5. https://doi.org/10.1097/BPO.0b013e318202c1f0

33. Kabirian, N et al. (2014). Deep surgical site infection following 2344 growing-rod procedures for early-onset scoliosis: Risk factors and clinical consequences. *Journal of Bone and Joint Surgery*, *96*(15), e128. https://doi.org/10.2106/JBJS.M.00618

34. Mineiro, J et al (2002). Subcutaneous rodding for progressive spinal curvatures: Early results: *Journal of Pediatric Orthopaedics*, *22*(3), 290–295. https://doi.org/10.1097/01241398-200205000-00004

35. Skaggs, D. L., et al (2015). Early onset scoliosis consensus statement, srs growing spine committee, 2015. *Spine Deformity*, *3*(2), 107. https://doi.org/10.1016/j.jspd.2015.01.002

36. Tis, J. E., et al (2012). Early onset scoliosis: Modern treatment and results. *Journal of Pediatric Orthopaedics*, *32*(7), 647–657. https://doi.org/10.1097/BPO.0b013e3182694f18

37. Hasler, C.-C., et al (2010). Efficacy and safety of VEPTR instrumentation for progressive spine deformities in young children without rib fusions. *European Spine Journal*, *19*(3), 400–408. https://doi.org/10.1007/s00586-009-1253-9

38. Watanabe, K., et al (2013). Risk factors for complications associated with growing-rod surgery for early-onset scoliosis: *Spine*, *38*(8), E464–E468. https://doi.org/10.1097/BRS.0b013e318288671a

39. Teoh, K. H. et al (2016). Do magnetic growing rods have lower complication rates compared with conventional growing rods? *The Spine Journal*, *16*(4), S40–S44. https://doi.org/10.1016/j.spinee.2015.12.099

40. Sucato, D. J. (2010). Management of severe spinal deformity: Scoliosis and kyphosis. *Spine*, *35*(25), 2186–2192. https://doi.org/10.1097/BRS.0b013e3181feab19

41. Campbell, R. M. (2009). Spine deformities in rare congenital syndromes: Clinical issues. *Spine*, *34*(17), 1815–1827. https://doi.org/10.1097/BRS.0b013e3181ab64e9

42. Cunin, V. (2015). Early-onset scoliosis – Current treatment. *Orthopaedics & Traumatology: Surgery & Research*, *101*(1), S109–S118. https://doi.org/10.1016/j.otsr.2014.06.032

43. Lebon, J., et al (2017). Magnetically controlled growing rod in early onset scoliosis: A 30-case multicenter study. *European Spine Journal*, *26*(6), 1567–1576. https://doi.org/10.1007/s00586-016-4929-y

44. Teoh, K. H., et al (2016). Magnetic controlled growing rods for early-onset scoliosis: A 4-year follow-up. *The Spine Journal*, *16*(4), S34–S39. https://doi.org/10.1016/j.spinee.2015.12.098

45. D'Astous, J. L., et al (2007). Casting and traction treatment methods for scoliosis. *Orthopedic Clinics of North America*, *38*(4), 477–484. https://doi.org/10.1016/j.ocl.2007.03.006

46. Fernandes, P et al (2007). Natural history of early onset scoliosis. *Journal of Bone and Joint Surgery*, *89*(suppl_1), 21–33. https://doi.org/10.2106/JBJS.F.00754

47. Ouellet, J. (2011). Surgical technique: Modern luqué trolley, a self-growing rod technique. *Clinical Orthopaedics & Related Research*, *469*(5), 1356–1367. https://doi.org/10.1007/s11999-011-1783-4

48. McCarthy, R. E., et al (2010). Shilla growing rods in a caprine animal model: A pilot study. *Clinical Orthopaedics & Related Research*, *468*(3), 705–710. https://doi.org/10.1007/s11999-009-1028-y

49. Hosseini, P., et al (2016). Magnetically controlled growing rods for early-onset scoliosis: A multicenter study of 23 cases with minimum 2 years follow-up. *Spine*, *41*(18), 1456–1462. https://doi.org/10.1097/BRS.0000000000001561

50. McCarthy, R. E., et al (2015). Shilla growth guidance for early-onset scoliosis: Results after a minimum of five years of follow-up. *Journal of Bone and Joint Surgery*, *97*(19), 1578–1584. https://doi.org/10.2106/JBJS.N.01083

51. Baulesh, D. M., et al (2012). The role of serial casting in early-onset scoliosis(Eos). *Journal of Pediatric Orthopaedics*, *32*(7), 658–663. https://doi.org/10.1097/BPO.0b013e318269c438

52. Corona, J., et al (2011). Measuring quality of life in children with early onsetscoliosis: Development and initial validation oftheearly onset scoliosis questionnaire. *Journal of Pediatric Orthopaedics*, *31*(2), 180–185. https://doi.org/10.1097/BPO.0b013e3182093f9f

53. Akbarnia, B. A., et al (2012). Innovation in growing rod technique: A study of safety and efficacy of a magnetically controlled growing rod in a porcine model. *Spine*, *37*(13), 1109–1114. https://doi.org/10.1097/BRS.0b013e318240ff67

54. Motoyama, E. K., et al (2009). Thoracic malformation with early-onset scoliosis: Effect of serial VEPTR expansion thoracoplasty on lung growth and function in children. *Paediatric Respiratory Reviews*, *10*(1), 12–17. https://doi.org/10.1016/j.prrv.2008.10.004

55. Jain, A., et al (2016). Avoidance of "final" surgical fusion after growing-rod treatment for early-onset scoliosis. *Journal of Bone and Joint Surgery*, *98*(13), 1073–1078. https://doi.org/10.2106/JBJS.15.01241

56. Schroerlucke, S. R., et al (2012). How does thoracic kyphosis affect patient outcomes in growing rod surgery? : *Spine*, *37*(15), 1303–1309. https://doi.org/10.1097/BRS.0b013e318246d8a0

57. Ridderbusch, K., et al (2017). Preliminary results of magnetically controlled growing rods for early onset scoliosis. *Journal of Pediatric Orthopaedics*, *37*(8), e575–e580. https://doi.org/10.1097/BPO.0000000000000752

58. Mahar, A. T., et al (2008). Biomechanical comparison of different anchors (Foundations) for the pediatric dual growing rod technique. *The Spine Journal*, *8*(6), 933–939. https://doi.org/10.1016/j.spinee.2007.10.031

59. Smith, J. T., et al (2015). A new classification system to report complications in growing spine surgery: A multicenter consensus study. *Journal of Pediatric Orthopaedics*, *35*(8), 798–803. https://doi.org/10.1097/BPO.0000000000000386

60. Rodillo, E., et al (1989). Scoliosis in spinal muscular atrophy: Review of 63 cases. *Journal of Child Neurology*, *4*(2), 118–123. https://doi.org/10.1177/088307388900400208

61. Matsumoto, H., et al (2018). The final 24-item early onset scoliosis questionnaires (EOSQ-24): Validity, reliability and responsiveness. *Journal of Pediatric Orthopaedics*, *38*(3), 144–151. https://doi.org/10.1097/BPO.0000000000000799

62. Vitale, M. G., et al (2011). Variability of expert opinion in treatment of early-onset scoliosis. *Clinical Orthopaedics & Related Research*, *469*(5), 1317–1322. https://doi.org/10.1007/s11999-010-1540-0

63. La Rosa, G., et al Oggiano, L., & Ruzzini, L. (2017). Magnetically controlled growing rods for the management of early -onset scoliosis: A preliminary report. *Journal of Pediatric Orthopaedics*, *37*(2), 79–85. https://doi.org/10.1097/BPO.0000000000000597

64. Watanabe, K., et al (2016). Risk factors for proximal junctional kyphosis associated with dual-rod growing-rod surgery for early-onset scoliosis. *Clinical Spine Surgery: A Spine Publication*, *29*(8), E428–E433. https://doi.org/10.1097/BSD.0000000000000127

65. Teoh, K. H., et al (2016). Metallosis following implantation of magnetically controlled growing rods in the treatment of scoliosis: A case series. *The Bone & Joint Journal*, *98-B*(12), 1662–1667. https://doi.org/10.1302/0301-620X.98B12.38061

66. Fletcher, N. D., et al (2012). Early onset scoliosis: Current concepts and controversies. *Current Reviews in Musculoskeletal Medicine*, *5*(2), 102–110. https://doi.org/10.1007/s12178-012-9116-0

67. Doany, M. E., et al. (2018). Health-related quality of life in early-onset scoliosis patients treated surgically: Eosq scores in traditional growing rod versus magnetically controlled growing rods. *Spine*, *43*(2), 148–153. https://doi.org/10.1097/BRS.0000000000002274

68. Noordeen, H. M., et al (2011). In vivo distraction force and length measurements of growing rods: Which factors influence the ability to lengthen? *Spine*, *36*(26), 2299–2303. https://doi.org/10.1097/BRS.0b013e31821b8e16

69. Cheung, J. P. Y., et al (2015). Special article: Update on the magnetically controlled growing rod: tips and pitfalls. *Journal of Orthopaedic Surgery*, *23*(3), 383–390. https://doi.org/10.1177/230949901502300327

70. Wang, S., et al (2012). Dual growing rods technique for congenital scoliosis: More than 2 years outcomes. *Spine*, *37*(26), E1639–E1644. https://doi.org/10.1097/BRS.0b013e318273d6bf

71. Redding, G. J., et al (2011). Structure-respiration function relationships before and after surgical treatment of early-onset scoliosis. *Clinical Orthopaedics & Related Research*, *469*(5), 1330–1334. https://doi.org/10.1007/s11999-010-1621-0

72. Thompson, W., et al (2016). The use of magnetically-controlled growing rods to treat children with early-onset scoliosis: Early radiological results in 19 children. *The Bone & Joint Journal*, *98-B*(9), 1240–1247. https://doi.org/10.1302/0301-620X.98B9.37545

73. Cheung, J. P. Y., et al (2019). Mean 6-year follow-up of magnetically controlled growing rod patients with early onset scoliosis: A glimpse of what happens to graduates. *Neurosurgery*, *84*(5), 1112–1123. https://doi.org/10.1093/neuros/nyy270

74. Yoon, W. W., et al (2014). Improvement of pulmonary function in children with early-onset scoliosis using magnetic growth rods: *Spine*, *39*(15), 1196–1202. https://doi.org/10.1097/BRS.0000000000000383

75. Rolton, D., et al 2015). Magnetic controlled growth rods versus conventional growing rod systems in the treatment of early onset scoliosis: A cost comparison. *European Spine Journal*, *24*(7), 1457–1461. https://doi.org/10.1007/s00586-014-3699-7

76. Joyce, T. J., et al (2018). Analysis of explanted magnetically controlled growing rods from seven uk spinal centers. *Spine*, *43*(1), E16–E22. https://doi.org/10.1097/BRS.0000000000002221

77. Karol, L. A. (2019). The natural history of early-onset scoliosis. *Journal of Pediatric Orthopaedics*, *39*(Supplement 1), S38–S43. https://doi.org/10.1097/BPO.0000000000001351

78. Gomez, J. A.et al (2011). "Growth friendly" spine surgery: Management options for the young child with scoliosis: *American Academy of Orthopaedic Surgeon*, *19*(12), 722–727. https://doi.org/10.5435/00124635-201112000-00002

79. Andras, L. M et al (2015). Growing rods versus shilla growth guidance: Better cobb angle correction and t1–s1 length increase but more surgeries. *Spine Deformity*, *3*(3), 246–252. https://doi.org/10.1016/j.jspd.2014.11.005

80. Shah, S. A et al (2014). The effect of serial growing rod lengthening on the sagittal profile and pelvic parameters in early-onset scoliosis: *Spine*, *39*(22), E1311–E1317. https://doi.org/10.1097/BRS.0000000000000565

81. Bylund, P et al (1987). Muscle fiber types in thoracic erector spinae muscles: Fiber types in idiopathic and other forms of scoliosis. *Clinical Orthopaedics and Related Research*, *214*(NA;), 222???228. https://doi.org/10.1097/00003086-198701000-00032

82. Phillips, J. H., et al (2013). Mortality and morbidity in early-onset scoliosis surgery: *Spine*, *38*(4), 324–327. https://doi.org/10.1097/BRS.0b013e31826c6743

83. Demirkiran, H. G et al (2015). Serial derotational casting in congenital scoliosis as a time-buying strategy. *Journal of Pediatric Orthopaedics*, *35*(1), 43–49. https://doi.org/10.1097/BPO.0000000000000229

84. Sankar, W. N., et al (2009). Neurologic risk in growing rod spine surgery in early onset scoliosis: Is neuromonitoring necessary for all cases? *Spine*, *34*(18), 1952–1955. https://doi.org/10.1097/BRS.0b013e3181afe869

85. Waldron, S. R., et al (2013). Early onset scoliosis: The value of serial risser casts. *Journal of Pediatric Orthopaedics*, *33*(8), 775–780. https://doi.org/10.1097/BPO.0000000000000072

86. Matsumoto, H. et al (2014). Psychosocial effects of repetitive surgeries in children with early-onset scoliosis: Are we putting them at risk? *Journal of Pediatric Orthopaedics*, *34*(2), 172–178. https://doi.org/10.1097/BPO.0b013e3182a11d73

87. Flynn, J. M., et al 2012). Psychological dysfunction in children who require repetitive surgery for early onset scoliosis. *Journal of Pediatric Orthopaedics*, *32*(6), 594–599. https://doi.org/10.1097/BPO.0b013e31826028ea

88. Charroin, C. et al (2014). Direct costs associated with the management of progressive early onset scoliosis: Estimations based on gold standard technique or with magnetically controlled growing rods. *Orthopaedics & Traumatology: Surgery & Research*, *100*(5), 469–474. https://doi.org/10.1016/j.otsr.2014.05.006

89. Dede, O., et al (2014). Pulmonary and radiographic outcomes of veptr (Vertical expandable prosthetic titanium rib) treatment in early-onset scoliosis. *Journal of Bone and Joint Surgery*, *96*(15), 1295–1302. https://doi.org/10.2106/JBJS.M.01218

90. Olgun, Z. D., et al (2012). Vertebral body growth during growing rod instrumentation: Growth preservation or stimulation? *Journal of Pediatric Orthopaedics*, *32*(2), 184–189. https://doi.org/10.1097/BPO.0b013e3182471915

91. Ahmad, A., et al. (2017). Quantifying the 'law of diminishing returns' in magnetically controlled growing rods. *The Bone & Joint Journal*, *99-B*(12), 1658–1664. https://doi.org/10.1302/0301-620X.99B12.BJJ-2017-0402.R2

92. Ramirez, N et al (2009). The Vertical Expandable Prosthetic Titanium Rib in the treatment of spinal deformity due to progressive early onset scoliosis. *Journal of Pediatric Orthopaedics B*, *18*(4), 197–203. https://doi.org/10.1097/BPB.0b013e32832bf5e0

93. Keskinen, H. et al (2016). Preliminary comparison of primary and conversion surgery with magnetically controlled growing rods in children with early onset scoliosis. *European Spine Journal*, *25*(10), 3294–3300. https://doi.org/10.1007/s00586-016-4597-y

94. Poe-Kochert, C. et al (2016). Final fusion after growing-rod treatment for early onset scoliosis: Is it really final? *Journal of Bone and Joint Surgery*, *98*(22), 1913–1917. https://doi.org/10.2106/JBJS.15.01334

95. Zhang, Y.-B. et al (2020). Treatment of early-onset scoliosis: Techniques, indications, and complications. *Chinese Medical Journal*, *133*(3), 351–357. https://doi.org/10.1097/CM9.0000000000000614

96. El-Hawary, R. et al (2017). What is the risk of developing proximal junctional kyphosis during growth friendly treatments for early-onset scoliosis? *Journal of Pediatric Orthopaedics*, *37*(2), 86–91. https://doi.org/10.1097/BPO.0000000000000599

97. Stokes, O. M et al (2014). Reducing radiation exposure in early-onset scoliosis surgery patients: Novel use of ultrasonography to measure lengthening in magnetically-controlled growing rods. *The Spine Journal*, *14*(10), 2397–2404. https://doi.org/10.1016/j.spinee.2014.01.039

98. Brooks, J. T et al (2016). What's new in the management of neuromuscular scoliosis. *Journal of Pediatric Orthopaedics*, *36*(6), 627–633. https://doi.org/10.1097/BPO.0000000000000497

99. White, K. K et al (2011). Veptr™ growing rods for early-onset neuromuscular scoliosis: Feasible and effective. *Clinical Orthopaedics & Related Research*, *469*(5), 1335–1341. https://doi.org/10.1007/s11999-010-1749-y

100. Mesfin, A et al (2012). Spinal muscular atrophy: Manifestations and management: *Journal of the American Academy of Orthopaedic Surgeons*, *20*(6), 393–401. https://doi.org/10.5435/JAAOS-20-06-393

101. Emans, J. B et al (2005). Prediction of thoracic dimensions and spine length based on individual pelvic dimensions in children and adolescents: An age-independent, individualized standard for evaluation of outcome in early onset spinal deformity. *Spine*, *30*(24), 2824–2829. https://doi.org/10.1097/01.brs.0000190865.47673.6a

102. Smith, J. T. (2011). Bilateral rib-to-pelvis technique for managing early-onset scoliosis. *Clinical Orthopaedics & Related Research*, *469*(5), 1349–1355. https://doi.org/10.1007/s11999-010-1700-2

103. Thompson, G. H. et al (2018). Does vancomycin powder decrease surgical site infections in growing spine surgery? : A preliminary study. *Journal of Bone and Joint Surgery*, *100*(6), 466–471. https://doi.org/10.2106/JBJS.17.00459

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