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**Table A.** Summary of selective dorsal rhizotomy (SDR) studies which are included in this review (Order by appearance).

Authors	Year Published	SDR cohort	Follow-up Time
Funk et al. <sup>3</sup>	2015	n = 54 SDR at 7 ± 2.9 years GMFCS level I & II	12 and 24 months
Dudley et al. <sup>4</sup>	2013	n = 102 SDR at 5 years GMFCS level I - III	1, 5, 10, and 15 years
Engsberg et al.⁵	2006	n = 31 SDR at 9 ± 5.3 years GMFCS level I - III	8 and 20 months
van Schie et al. <sup>7</sup>	2011	n = 33 SDR at 7 ± 2 years GMFCS level I - III	1 and 6 years
Cole et al. <sup>12</sup>	2007	n = 19 SDR at 9 years GMFCS level I - IV	18 months
Romei et al. <sup>13</sup>	2018	n = 19 SDR at 7 ± 1.6 years GMFCS level I - III	2, 5, and 10 years
Daunter et al. <sup>14</sup>	2017	n = 38 SDR at age < 10 years GMFCS level I - V	22 years
Hurvitz et al. <sup>16</sup>	2013	n = 88 SDR at 6 ± 3.9 years GMFCS level I-V	20 years
Munger et al. <sup>17</sup>	2017	n = 24 SDR at 5 ± 0.8 years GMFCS level I-IV	13 years (range: 10-17 years)
Peacock et al. <sup>28</sup>	1982	n = 15 SDR at 22 months - 16 years GMFCS level was not reported	4 - 16 months
Ou et al. <sup>30</sup>	2010	n = 27 SDR at 6 ± 1.6 years GMFCS level was not reported	n/a (in patient)
O'Brien et al. <sup>32</sup>	2006	n = 178 SDR at 2-19 years GMFCS level was not reported	44 months (range: 24-70 months)
Steinbok et al. <sup>34</sup>	2009	n = 22 SDR at 6 ± 4.5 years GMFCS level was not reported	1 year
Sacco et al. <sup>35</sup>	2000	n = 10	12 months

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		SDR at 8.5 years (5-16)	(range: 10-14 months)
<b>C I I I 3 C</b>	2018	GMFCS level was not reported	
Georgoulis et al. <sup>36</sup>	2018	n = 13 SDR at 9 years (6-16)	n/a (intraoperative report)
		GMFCS level II-V	
D'Aquino et al. <sup>37</sup>	2019		2.9 and 14 months
D'Aquino et al.º	2018	n = 54	2, 8, and 14 months
		SDR at 10.2 years (3-20)	
<b>a</b> 1 1 38	0.007	GMFCS level IV & V	
Golan et al. <sup>38</sup>	2007	n = 98	5.8 years
		SDR at 5.1 years (3-11)	(range: 1.1-11.5 years)
20		GMFCS level was not reported	
Johnson et al. <sup>39</sup>	2004	n = 45	5.0-11.6 years
		SDR at 6.0 years (4-11)	
		GMFCS level was not reported	
Langerak et al. <sup>40</sup>	2009	n = 30	17-26 years
		SDR at 5 ± 5 years (2-27)	
		GMFCS level I-III	
Li et al. <sup>41</sup>	2008	n = 61	6.3 years
		SDR at 6.9 years (3-20)	(range: 5-9 years)
		GMFCS level was not reported	
Trost et al.42	2008	n = 136	18 ± 4.4 years
		SDR at 7 ± 1.1 years	
		GMFCS level I-IV	
Langerak et al.45	2012	n = 31	21 ± 2.9 years
		SDR at 5.2 years (2–27)	(range: 17–26 years)
		GMFCS level I-III	(
Subramanian et al. <sup>46</sup>	1998	n = 11	1, 3, and 10 years
		SDR at 7.8 years (3-13)	_, _, _, , , ,
		GMFCS level was not reported	
Wong et al.47	2005	n = 20	3, 6, 12, and 20 months
wong et al.	2005	SDR age was not reported	5, 0, 12, and 20 months
		GMFCS level was not reported	
Engsberg et al. <sup>48</sup>	2007	n = 31	2 years
	2007	SDR at 9 $\pm$ 4.8 years	2 years
		GMFCS level I-III	
Grunt et al. <sup>49</sup>	2010	n = 19	5.3 ± 2.8 years
	2010	n = 19 SDR at 7 ± 1.5 years	(range: 1-9 years)
		GMFCS level I-III	(range. 1-3 years)
Grunt et al. <sup>50</sup>	2010		12 and 24 months
Grunt et al.	2010	n = 30	12 and 24 months
		SDR at 7 $\pm$ 2.0 years	
La a a b a a 1 51	2015	GMFCS level I-III	
Josenby et al. <sup>51</sup>	2015	n = 29	5 and 10 years
		SDR at 4 ± 2.5 years	
		GMFCS level I-IV	
Bolster et al. <sup>52</sup>	2013	n = 29	5 and 10 years
		SDR at 6 ± 2.9 years	
		GMFCS level I-III	
Steinbok et al. <sup>56</sup>	1997	n = 14	9 months
		SDR at 2.9-6.3 years	

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		GMFCS level was not reported	
Wright et al. <sup>57</sup>	1998	n = 24 SDR at 5 ± 1.1 years (3-8) GMFCS level was not reported	6 and 12 months
Chan et al. <sup>58</sup>	2008	n = 21 SDR at 9 ± 2.6 years GMFCS level I-IV	2 weeks, 3 months, 6 months, and 1 year
Mittal et al. <sup>59</sup>	2002	n = 71 SDR at 5.2 years (3-11) GMFCS level was not reported	6 months, 1, 3, and 5 years
McLaughlin et al. <sup>60</sup>	1998	n = 21 SDR at 6 ± 3.0 years (3-14) GMFCS level was not reported	6, 12, and 24 months
MacWilliams et al. <sup>61</sup>	2011	n = 8 SDR at 15 ± 3.0 years GMFCS level I & II	12-36 months
Abel et al. <sup>62</sup>	2005	n = 10 SDR at 8.5 years (3-15) GMFCS level I-III	10.7 months (range: 9-12 months)
Thomas et al. <sup>63</sup>	1996	n = 26 SDR at 6.3 years (4-11) GMFCS level was not reported	1 year
Nordmark et al. <sup>68</sup>	2008	n = 35 SDR at 4.5 years (3-7) GMFCS level I-V	6, 12, 18 months, 3 and 5 years
Graubert et al. <sup>69</sup>	2000	n = 18 SDR at 6.5 years (3-15) GMFCS level was not reported	1 year
Steinbok et al. <sup>70</sup>	2002	n = 13 SDR at 2.9-6.3 years GMFCS level was not reported	63 months (range: 34-85 months)
Engsberg et al. <sup>71</sup>	2002	n = 24 SDR at 8 ± 4.3 years (4-18) GMFCS level I-III	was not reported
Buckon et al. <sup>72</sup>	2002	n = 10 SDR at 5.3 years (4-7) GMFCS level was not reported	6 and 12 months
Josenby et al. <sup>73</sup>	2012	n = 29 SDR at 4.3 years (3-7) GMFCS level I-IV	15 years (range: 13-17 years)
Langerak et al. <sup>74</sup>	2011	n = 31 SDR at 5.2 years (2-27) GMFCS level I-III	21.3 years (range: 17-26 years)
Tedroff et al. <sup>75</sup>	2011	n = 19 SDR at 5 ± 1.6 years GMFCS level	10 years
Langerak et al. <sup>76</sup>	2008	n = 13 SDR at 7.3 years (2-14) GMFCS level was not reported	1, 3, 10, and 20 years

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Oki et al. <sup>77</sup>	2010	n = 13	8.7 months
		SDR at 6.6 years (3-12)	(range: 4-22 months)
		GMFCS level was not reported	
van de Pol et al. <sup>83</sup>	2018	n = 18	n/a
		SDR at 2-19 years	
		GMFCS level IV & V	
Abdel Ghany et al. <sup>84</sup>	2016	n = 50	12 months
		SDR at 7.9 years (4-18)	
Albright et al. <sup>85</sup>	2007	GMFCS level was not reported n = 6	1 months 2 years
Albright et al.	2007	SDR at 10 $\pm$ 2.3 years	1 months - 2 years
		GMFCS level was not reported	
Buckon et al. <sup>87</sup>	2004	n = 18	6 and 12 months
Bucken et un	2001	SDR at 59 years (4-10)	
		GMFCS level I-III	
Oudenhoven et al. <sup>94</sup>	2018	n = 36	5 years
		SDR at 7 ± 1.9 years (4-13)	
		GMFCS level I-III	
Engsberg et al. <sup>96</sup>	1999	n = 25	8 months
		SDR age was not reported	
		GMFCS level was not reported	
McFall et al. <sup>98</sup>	2015	n = 17	5 and 10 years
		SDR at $8 \pm 8.3$ years	
Tedroff et al. <sup>100</sup>	2015	GMFCS level II-IV n = 19	17 years
leuron et al.	2015	SDR at 5 $\pm$ 1.6 years	17 years
		GMFCS level I-V	
O'Brien et al. <sup>102</sup>	2005	n = 158	5-9 years
		SDR at 2-14 years	
		GMFCS level was not reported	
Kim et al. <sup>103</sup>	2006	n = 174	1 year
		SDR at 5.5 years (2-18)	
		GMFCS level I-V	
Chicoine et al. <sup>113</sup>	1997	n = 178	44 months
		SDR at 5.5 years (2-19)	(range: 24-70 months)
Correll at al 114	1000	GMFCS level	7.0
Carroll et al. <sup>114</sup>	1998	n = 112 SDR at 7 years (3-17)	7.9 years
		GMFCS level was not reported	
Park et al. <sup>115</sup>	2017	n = 95	24.3 ± 2.2 years
	_•_	SDR at 2-18 years	(range: 20-28 years)
		GMFCS level I-V	,,
Dudgeon et al. <sup>116</sup>	1994	n = 29	12 months
		SDR at 8 ± 4.1 years (4-22)	
		GMFCS level was not reported	

## References

1. Rosenbaum P. Cerebral palsy: what parents and doctors want to know. BMJ 2003; 326: 970–974.

2. Nahm NJ, Graham HK, Gormley ME Jr, et al. Management of hypertonia in cerebral palsy. Curr Opin Pediatr 2018; 30: 57–64.

3. Funk JF, Panthen A, Bakir MS, et al. Predictors for the benefit of selective dorsal rhizotomy. Res Dev Disabil 2015; 37: 127–134.

4. Dudley RWR, Parolin M, Gagnon B, et al. Long-term functional benefits of selective dorsal rhizotomy for spastic cerebral palsy. J Neurosurg Pediatr 2013; 12: 142–150.

5. Engsberg JR, Ross SA, Collins DR, et al. Effect of selective dorsal rhizotomy in the treatment of children with cerebral palsy. J Neurosurg 2006; 105: 8–15.

6. McLaughlin J, Bjornson K, Temkin N, et al. Selective dorsal rhizotomy: meta-analysis of three randomized controlled trials. Dev Med Child Neurol 2002; 44: 17–25.

7. van Schie PEM, Schothorst M, Dallmeijer AJ, et al. Short- and long-term effects of selective dorsal rhizotomy on gross motor function in ambulatory children with spastic diplegia. J Neurosurg Pediatr 2011; 7: 557–562.

8. Abou Al-Shaar H, Imtiaz MT, Alhalabi H, et al. Selective dorsal rhizotomy: A multidisciplinary approach to treating spastic diplegia. Asian J Neurosurg 2017; 12: 454–465.

9. Farmer J-P, Sabbagh AJ. Selective dorsal rhizotomies in the treatment of spasticity related to cerebral palsy. Childs Nerv Syst 2007; 23: 991–1002.

10. Wang KK, Munger ME, Chen BP-J, et al. Selective dorsal rhizotomy in ambulant children with cerebral palsy. J Child Orthop 2018; 12: 413–427.

11. Aquilina K, Graham D, Wimalasundera N. Selective dorsal rhizotomy: an old treatment re-emerging. Arch Dis Child 2015; 100: 798–802.

12. Cole GF, Farmer SE, Roberts A, et al. Selective dorsal rhizotomy for children with cerebral palsy: the Oswestry experience. Arch Dis Child 2007; 92: 781–785.

13. Romei M, Oudenhoven LM, van Schie PEM, et al. Evolution of gait in adolescents and young adults with spastic diplegia after selective dorsal rhizotomy in childhood: A 10 year follow-up study. Gait Posture 2018; 64: 108–113.

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14. Daunter AK, Kratz AL, Hurvitz EA. Long-term impact of childhood selective dorsal rhizotomy on pain, fatigue, and function: a case--control study. Dev Med Child Neurol 2017; 59: 1089–1095.

15. Oudenhoven L, van der Krogt M, Buizer A. Selective motor control before and after selective dorsal rhizotomy in ambulant children with cerebral palsy. Gait Posture 2016; 49: 29.

16. Hurvitz EA, Marciniak CM, Daunter AK, et al. Functional outcomes of childhood dorsal rhizotomy in adults and adolescents with cerebral palsy. J Neurosurg Pediatr 2013; 11: 380–388.

17. Munger ME, Aldahondo N, Krach LE, et al. Long-term outcomes after selective dorsal rhizotomy: a retrospective matched cohort study. Dev Med Child Neurol 2017; 59: 1196–1203.

18. Grunt S, Fieggen AG, Vermeulen RJ, et al. Selection criteria for selective dorsal rhizotomy in children with spastic cerebral palsy: a systematic review of the literature. Dev Med Child Neurol 2014; 56: 302–312.

19. Graham D, Aquilina K, Cawker S, et al. Single-level selective dorsal rhizotomy for spastic cerebral palsy. Journal of Spine Surgery 2016; 2: 195–201.

20. Nicolini-Panisson RD, Tedesco AP, Folle MR, et al. Selective dorsal rhizotomy in cerebral palsy: selection criteria and postoperative physical therapy protocols. Rev Paul Pediatr 2018; 36: 9.

21. Graham D, Aquilina K, Mankad K, et al. Selective dorsal rhizotomy: current state of practice and the role of imaging. Quant Imaging Med Surg 2018; 8: 209–218.

22. van Schie PEM, Vermeulen RJ, van Ouwerkerk WJR, et al. Selective dorsal rhizotomy in cerebral palsy to improve functional abilities: evaluation of criteria for selection. Childs Nerv Syst 2005; 21: 451–457.

23. Peacock WJ, Arens LJ, Berman B. Cerebral palsy spasticity. Selective posterior rhizotomy. Pediatr Neurosci 1987; 13: 61–66.

24. Gros C, Ouaknine G, Vlahovitch B, et al. Selective posterior radicotomy in the neurosurgical treatment of pyramidal hypertension. Neurochirurgie 1967; 13: 505–518.

25. Foerster O. Resection of the posterior spinal nerve roots in the treatment of gastric crises and spastic paralysis. Proc R Soc Med. 1911;4(Surg Sect):226-246.

26. Fasano VA, Barolat-Romana G, Ivaldi A, et al. Functional posterior radiculotomy, in the treatment of cerebral spasticity. Peroperative electric stimulation of posterior roots and its use in the choice of the roots to be sectioned. Neurochirurgie 1976; 22: 23–34.

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27. Fasano VA, Barolat-Romana G, Zeme S, et al. Electrophysiological assessment of spinal circuits in spasticity by direct dorsal root stimulation. Neurosurgery 1979; 4: 146–151.

28. Peacock WJ, Arens LJ. Selective posterior rhizotomy for the relief of spasticity in cerebral palsy. S Afr Med J 1982; 62: 119–124.

29. Park TS, Gaffney PE, Kaufman BA, et al. Selective lumbosacral dorsal rhizotomy immediately caudal to the conus medullaris for cerebral palsy spasticity. Neurosurgery 1993; 33: 929–33; discussion 933–4.

30. Ou C, Kent S, Miller S, et al. Selective dorsal rhizotomy in children: comparison of outcomes after single-level versus multi-level laminectomy technique. Can J Neurosci Nurs 2010; 32: 17–24.

31. Steinbok P. Selective dorsal rhizotomy for spastic cerebral palsy: a review. Childs Nerv Syst 2007; 23: 981–990.

32. O'Brien DF, Park TS. A review of orthopedic surgeries after selective dorsal rhizotomy. Neurosurg Focus 2006; 21: e2.

33. Park TS, Johnston JM. Surgical techniques of selective dorsal rhizotomy for spastic cerebral palsy. Technical note. Neurosurg Focus 2006; 21: e7.

34. Steinbok P, Tidemann AJ, Miller S, et al. Electrophysiologically guided versus nonelectrophysiologically guided selective dorsal rhizotomy for spastic cerebral palsy: a comparison of outcomes. Childs Nerv Syst 2009; 25: 1091–1096.

35. Sacco DJ, Tylkowski CM, Warf BC. Nonselective partial dorsal rhizotomy: a clinical experience with 1-year follow-Up. Pediatr Neurosurg 2000; 32: 114–118.

36. Georgoulis G, Brînzeu A, Sindou M. Dorsal rhizotomy for children with spastic diplegia of cerebral palsy origin: usefulness of intraoperative monitoring. J Neurosurg Pediatr 2018; 22: 89–101.

37. D'Aquino D, Moussa AA, Ammar A, et al. Selective dorsal rhizotomy for the treatment of severe spastic cerebral palsy: efficacy and therapeutic durability in GMFCS grade IV and V children. Acta Neurochir 2018; 160: 811–821.

38. Golan JD, Hall JA, O'Gorman G, et al. Spinal deformities following selective dorsal rhizotomy. J Neurosurg 2007; 106: 441–449.

39. Johnson MB, Goldstein L, Thomas SS, et al. Spinal deformity after selective dorsal rhizotomy in ambulatory patients with cerebral palsy. J Pediatr Orthop 2004; 24: 529–536.

Page 8

40. Langerak NG, Vaughan CL, Hoffman EB, et al. Incidence of spinal abnormalities in patients with spastic diplegia 17 to 26 years after selective dorsal rhizotomy. Childs Nerv Syst 2009; 25: 1593–1603.

41. Li Z, Zhu J, Liu X. Deformity of lumbar spine after selective dorsal rhizotomy for spastic cerebral palsy. Microsurgery 2008; 28: 10–12.

42. Trost JP, Schwartz MH, Krach LE, et al. Comprehensive short-term outcome assessment of selective dorsal rhizotomy. Dev Med Child Neurol 2008; 50: 765–771.

43. Enslin JMN, Langerak NG, Fieggen AG. The evolution of selective dorsal rhizotomy for the management of spasticity. Neurotherapeutics. 2019; 16: 3-8.

44. Grunt S, Becher JG, Vermeulen RJ. Long-term outcome and adverse effects of selective dorsal rhizotomy in children with cerebral palsy: a systematic review. Dev Med Child Neurol 2011; 53: 490–498.

45. Langerak NG, Tam N, Vaughan CL, et al. Gait status 17-26 years after selective dorsal rhizotomy. Gait Posture 2012; 35: 244–249.

46. Subramanian N, Vaughan CL, Peter JC, et al. Gait before and 10 years after rhizotomy in children with cerebral palsy spasticity. J Neurosurg 1998; 88: 1014–1019.

47. Wong AMK, Pei Y-C, Lui T-N, et al. Comparison between botulinum toxin type A injection and selective posterior rhizotomy in improving gait performance in children with cerebral palsy. J Neurosurg 2005; 102: 385–389.

48. Engsberg JR, Ross SA, Collins DR, et al. Predicting functional change from preintervention measures in selective dorsal rhizotomy. J Neurosurg 2007; 106: 282–287.

49. Grunt S, Becher JG, van Schie P, et al. Preoperative MRI findings and functional outcome after selective dorsal rhizotomy in children with bilateral spasticity. Childs Nerv Syst 2010; 26: 191–198.

50. Grunt S, Henneman WJP, Bakker MJ, et al. Effect of selective dorsal rhizotomy on gait in children with bilateral spastic paresis: kinematic and EMG-pattern changes. Neuropediatrics 2010; 41: 209–216.

51. Josenby AL, Wagner P, Jarnlo G-B, et al. Functional performance in self-care and mobility after selective dorsal rhizotomy: a 10-year practice-based follow-up study. Dev Med Child Neurol 2015; 57: 286–293.

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52. Bolster EAM, van Schie PEM, Becher JG, et al. Long-term effect of selective dorsal rhizotomy on gross motor function in ambulant children with spastic bilateral cerebral palsy, compared with reference centiles. Dev Med Child Neurol 2013; 55: 610–616.

53. Harvey A, Rosenbaum P, Graham HK, et al. Current and future uses of the Gross Motor Function Classification System. Dev Med Child Neurol 2009; 51: 328–329.

54. Graham HK, Harvey A, Rodda J, et al. The Functional Mobility Scale (FMS). J Pediatr Orthop 2004; 24: 514–520.

55. Russell DJ, Avery LM, Rosenbaum PL, et al. Improved scaling of the gross motor function measure for children with cerebral palsy: evidence of reliability and validity. Phys Ther 2000; 80: 873–885.

56. Steinbok P, Reiner AM, Beauchamp R, et al. A randomized clinical trial to compare selective posterior rhizotomy plus physiotherapy with physiotherapy alone in children with spastic diplegic cerebral palsy. Dev Med Child Neurol 1997; 39: 178–184.

57. Wright FV, Sheil EMH, Drake JM, et al. Evaluation of selective dorsal rhizotomy for the reduction of spasticity in cerebral palsy: a randomized controlled trial. Dev Med Child Neurol 1998; 40: 239–247.

58. Chan SH-S, Yam KY, Yiu-Lau BP-H, et al. Selective dorsal rhizotomy in Hong Kong: multidimensional outcome measures. Pediatr Neurol 2008; 39: 22–32.

59. Mittal S, Farmer J-P, Al-Atassi B, et al. Long-term functional outcome after selective posterior rhizotomy. J Neurosurg 2002; 97: 315–325.

60. McLaughlin JF, Bjornson KF, Astley SJ, et al. Selective dorsal rhizotomy: efficacy and safety in an investigator-masked randomized clinical trial. Dev Med Child Neurol 1998; 40: 220–232.

61. MacWilliams BA, Johnson BA, Shuckra AL, et al. Functional decline in children undergoing selective dorsal rhizotomy after age 10. Dev Med Child Neurol 2011; 53: 717–723.

62. Abel MF, Damiano DL, Gilgannon M, et al. Biomechanical changes in gait following selective dorsal rhizotomy. J Neurosurg Pediatr 2005; 102: 157–162.

63. Thomas SS, Aiona MD, Pierce R, et al. Gait changes in children with spastic diplegia after selective dorsal rhizotomy. J Pediatr Orthop 1996; 16: 747–752.

64. Hanna SE, Rosenbaum PL, Bartlett DJ, et al. Stability and decline in gross motor function among children and youth with cerebral palsy aged 2 to 21 years. Dev Med Child Neurol 2009; 51: 295–302.

65. Hägglund G, Wagner P. Development of spasticity with age in a total population of children with cerebral palsy. BMC Musculoskelet Disord 2008; 9: 150.

66. Baker R, Graham K. [Commentary] MacWilliams: Functional decline in children undergoing selective dorsal rhizotomy after age 10. Dev Med Child Neurol 2011; 53: 677.

67. Stanley FJ, Blair E, Alberman E. Cerebral Palsies: Epidemiology and Causal Pathways. London: MacKeith, 2000.

68. Nordmark E, Josenby AL, Lagergren J, et al. Long-term outcomes five years after selective dorsal rhizotomy. BMC Pediatr 2008; 8: 54.

69. Graubert C, Song KM, McLaughlin JF, et al. Changes in gait at 1 year post-selective dorsal rhizotomy: results of a prospective randomized study. J Pediatr Orthop 2000; 20: 496–500.

70. Steinbok P, McLeod K. Comparison of motor outcomes after selective dorsal rhizotomy with and without preoperative intensified physiotherapy in children with spastic diplegic cerebral palsy. Pediatr Neurosurg 2002; 36: 142–147.

71. Engsberg JR, Ross SA, Wagner JM, et al. Changes in hip spasticity and strength following selective dorsal rhizotomy and physical therapy for spastic cerebral palsy. Dev Med Child Neurol 2002; 44: 220–226.

72. Buckon CE, Thomas SS, Harris GE, et al. Objective measurement of muscle strength in children with spastic diplegia after selective dorsal rhizotomy. Arch Phys Med Rehabil 2002; 83: 454–460.

73. Josenby AL, Wagner P, Jarnlo G-B, et al. Motor function after selective dorsal rhizotomy: a 10-year practice-based follow-up study. Dev Med Child Neurol 2012; 54: 429–435.

74. Langerak NG, Hillier SL, Verkoeijen PP, et al. Level of Activity and Participation in Adults with Spastic Diplegia 17–26 Years After Selective Dorsal Rhizotomy. J Rehabil Med 2011; 43: 330–337.

75. Tedroff K, Löwing K, Jacobson DNO, et al. Does loss of spasticity matter? A 10-year follow-up after selective dorsal rhizotomy in cerebral palsy. Dev Med Child Neurol 2011; 53: 724–729.

76. Langerak NG, Lamberts RP, Fieggen AG, et al. A prospective gait analysis study in patients with diplegic cerebral palsy 20 years after selective dorsal rhizotomy. J Neurosurg Pediatr 2008; 1: 180–186.

77. Oki A, Oberg W, Siebert B, et al. Selective dorsal rhizotomy in children with spastic hemiparesis. J Neurosurg Pediatr 2010; 6: 353–358.

78. Naidoo P. Current practices in the assessment of hypotonia in children. South African Journal of Occupational Therapy 2013; 43: 12–17.

79. Jethwa A, Mink J, Macarthur C, et al. Development of the Hypertonia Assessment Tool (HAT): a discriminative tool for hypertonia in children. Dev Med Child Neurol 2009; 52: e83–e87.

80. Knights S, Datoo N, Kawamura A, et al. Further evaluation of the scoring, reliability, and validity of the Hypertonia Assessment Tool (HAT). J Child Neurol 2014; 29: 500–504.

81. Ashworth B. Preliminary trial of carisoprodol in multiple sclerosis. Practitioner 1964; 192: 540–542.

82. Morris SL, Williams G. A historical review of the evolution of the Tardieu Scale. Brain Inj 2018; 32: 665–669.

83. van de Pol LA, Vermeulen RJ, van't Westende C, et al. Risk Factors for Dystonia after Selective Dorsal Rhizotomy in Nonwalking Children and Adolescents with Bilateral Spasticity. Neuropediatrics 2018; 49: 44–50.

84. Abdel Ghany WA, Nada M, Mahran MA, et al. Combined Anterior and Posterior Lumbar Rhizotomy for Treatment of Mixed Dystonia and Spasticity in Children With Cerebral Palsy. Neurosurgery 2016; 79: 336–344.

85. Albright AL, Tyler-Kabara EC. Combined ventral and dorsal rhizotomies for dystonic and spastic extremities. Report of six cases. J Neurosurg 2007; 107: 324–327.

86. Schwartz MH, Rozumalski A, Steele KM. Dynamic motor control is associated with treatment outcomes for children with cerebral palsy. Dev Med Child Neurol 2016; 58: 1139–1145.

87. Buckon CE, Thomas SS, Piatt JH Jr, et al. Selective dorsal rhizotomy versus orthopedic surgery: a multidimensional assessment of outcome efficacy 1. Arch Phys Med Rehabil 2004; 85: 457–465.

88. Roberts A, Stewart C, Freeman R. Gait analysis to guide a selective dorsal rhizotomy program. Gait Posture 2015; 42: 16–22.

89. Lebiedowska MK, Gaebler-Spira D, Burns RS, et al. Biomechanic characteristics of patients with spastic and dystonic hypertonia in cerebral palsy. Arch Phys Med Rehabil 2004; 85: 875–880.

90. Beattie C, Gormley M, Wervey R, et al. An electromyographic protocol that distinguishes spasticity from dystonia. J Pediatr Rehabil Med 2016; 9: 125–132.

91. Bax M, Tydeman C, Flodmark O. Clinical and MRI correlates of cerebral palsy: the European Cerebral Palsy Study. JAMA 2006; 296: 1602–1608.

92. Rogers B, Msall M, Owens T, et al. Cystic periventricular leukomalacia and type of cerebral palsy in preterm infants. J Pediatr 1994; 125: S1–8.

93. de Vries LS, Eken P, Groenendaal F, et al. Correlation between the degree of periventricular leukomalacia diagnosed using cranial ultrasound and MRI later in infancy in children with cerebral palsy. Neuropediatrics 1993; 24: 263–268.

94. Oudenhoven LM, van der Krogt MM, Romei M, et al. Factors Associated With Long-Term Improvement of Gait After Selective Dorsal Rhizotomy. Arch Phys Med Rehabil. 2019; 100: 474-480.

95. Graham HK, Rosenbaum P, Paneth N, et al. Cerebral palsy. Nat Rev Dis Primers 2016; 2: 15082.

96. Engsberg JR, Ross SA, Park TS. Changes in ankle spasticity and strength following selective dorsal rhizotomy and physical therapy for spastic cerebral palsy. J Neurosurg 1999; 91: 727–732.

97. Damiano DL, Dodd K, Taylor NF. Should we be testing and training muscle strength in cerebral palsy? Dev Med Child Neurol 2002; 44: 68–72.

98. McFall J, Stewart C, Kidgell V, et al. Changes in gait which occur before and during the adolescent growth spurt in children treated by selective dorsal rhizotomy. Gait Posture 2015; 42: 317–322.

99. Manikowska F, Chen BP-J, Jóźwiak M, et al. Validation of Manual Muscle Testing (MMT) in children and adolescents with cerebral palsy. NeuroRehabilitation 2018; 42: 1–7.

100. Tedroff K, Löwing K, Åström E. A prospective cohort study investigating gross motor function, pain, and health-related quality of life 17 years after selective dorsal rhizotomy in cerebral palsy. Dev Med Child Neurol 2015; 57: 484–490.

101. Mugglestone MA, Eunson P, Murphy MS, et al. Spasticity in children and young people with non-progressive brain disorders: summary of NICE guidance. BMJ 2012; 345: e4845.

102. O'Brien DF, Park TS, Puglisi JA, et al. Orthopedic surgery after selective dorsal rhizotomy for spastic diplegia in relation to ambulatory status and age. J Neurosurg 2005; 103: 5–9.

103. Kim HS, Steinbok P, Wickenheiser D. Predictors of poor outcome after selective dorsal rhizotomy in treatment of spastic cerebral palsy. Childs Nerv Syst 2006; 22: 60–66.

104. Novacheck TF, Gage JR. Orthopedic management of spasticity in cerebral palsy. Childs Nerv Syst 2007; 23: 1015–1031.

105. García Íñiguez JA, Vásquez Garibay EM, García Contreras AA, et al. Energy expenditure is associated with age, anthropometric indicators and body composition in children with spastic cerebral palsy. Nutr Hosp 2018; 35: 909–913.

106. Kamp FA, Lennon N, Holmes L, et al. Energy cost of walking in children with spastic cerebral palsy: relationship with age, body composition and mobility capacity. Gait Posture 2014; 40: 209–214.

107. Johnston TE, Moore SE, Quinn LT, et al. Energy cost of walking in children with cerebral palsy: relation to the Gross Motor Function Classification System. Dev Med Child Neurol 2004; 46: 34–38.

108. Bell KL, Davies PSW. Energy expenditure and physical activity of ambulatory children with cerebral palsy and of typically developing children--. Am J Clin Nutr 2010; 92: 313–319.

109. Morrell DS, Pearson JM, Sauser DD. Progressive bone and joint abnormalities of the spine and lower extremities in cerebral palsy. Radiographics 2002; 22: 257–268.

110. Gage JR, Schwartz MH, Koop SE, et al. The Identification and Treatment of Gait Problems in Cerebral Palsy. John Wiley & Sons, 2009.

111. Graham HK, Aoki KR, Autti-Rämö I, et al. Recommendations for the use of botulinum toxin type A in the management of cerebral palsy. Gait Posture 2000; 11: 67–79.

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112. Dumas HM, O'neil ME, Fragala MA. Expert consensus on physical therapist intervention after botulinum toxin a injection for children with cerebral palsy. Pediatr Phys Ther 2001; 13: 122–132.

113. Chicoine MR, Park TS, Kaufman BA. Selective dorsal rhizotomy and rates of orthopedic surgery in children with spastic cerebral palsy. J Neurosurg 1997; 86: 34–39.

114. Carroll KL, Moore KR, Stevens PM. Orthopedic procedures after rhizotomy. J Pediatr Orthop 1998; 18: 69–74.

115. Park TS, Liu JL, Edwards C, et al. Functional Outcomes of Childhood Selective Dorsal Rhizotomy 20 to 28 Years Later. Cureus 2017; 9: e1256.

116. Dudgeon BJ, Libby AK, McLaughlin JF, et al. Prospective measurement of functional changes after selective dorsal rhizotomy. Arch Phys Med Rehabil 1994; 75: 46–53.

117. Eek MN, Tranberg R, Zügner R, et al. Muscle strength training to improve gait function in children with cerebral palsy. Dev Med Child Neurol 2008; 50: 759–764.

118. Cerebral Palsy Research Network (CPRN), https://cprn.org/cerebral-palsy-research/.

119. American Physical Therapy Association (APTA): Clinical Practice Guidelines (CPGs), http://www.apta.org/EvidenceResearch/EBPTools/CPGs/