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# Supplementary Material

10.1302/0301-620X.104B4.BJJ-2021-1677.R1

## Detailed search strategies and search words across databases

## Embase search

| # | Searches |
|---|---|
| 1 | exp adolescent idiopathic scoliosis/ |
| 2 | prognosis/ |
| 3 | disease course/ |
| 4 | disease exacerbation/ |
| 5 | treatment outcome/ or clinical outcome/ |
| 6 | 2 or 3 or 4 or 5 |
| 7 | (progress* or prognos* or outcome*).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word] |
| 8 | radiography/ |
| 9 | nuclear magnetic resonance imaging/ |
| 10 | echography/ |
| 11 | imaging/ |
| 12 | X ray/ |
| 13 | 8 or 9 or 10 or 11 or 12 |
| 14 | (imaging or X ray* or magnetic resonance imaging or ultraso* or radiogra* or roentgenogra* or skiagra*).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word] |
| 15 | 13 or 14 |
| 16 | 6 or 7 |
| 17 | 1 and 15 and 16 |

18 limit 17 to dc=19470101-20201231

## Medline search

| # | Searches |
|---|---|
| 1 | Scoliosis/ |
| 2 | Adolescent/ |
| 3 | 'adolescent idiopathic scoliosis'.mp. |
| 4 | 1 and 2 |
| 5 | 3 or 4 |
| 6 | disease progression/ |
| 7 | Prognosis/ |
| 8 | ('disease exacerbation' or 'disease course' or 'treatment outcome' or 'clinical outcome' or 'progress*' or 'outcome*' or 'prognos*').mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] |
| 9 | 6 or 7 or 8 |
| 10 | Radiography/ |
| 11 | Magnetic Resonance Imaging/ |
| 12 | Ultrasonography/ |
| 13 | ('Nuclear magnetic resonance imaging' or 'echogra*' or 'imaging' or 'X$ray' or 'radiogra*' or 'MRI' or 'roentgenogra*' or 'skiagra*').mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] |
| 14 | 10 or 11 or 12 or 13 |
| 15 | 5 and 9 and 14 |
| 16 | limit 15 to dt=19000101-20201231 |

## Web of Science search

| # | Searches |
|---|---|
| 1 | ALL=(adolescen* AND idiopathic scolios?s)<br>*Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=1956-2020* |
| 2 | ALL=(progress* OR prognos* OR outcome* OR exacerbation OR disease course)<br>*Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=1956-2020* |
| 3 | ALL=(imaging* OR X ray* OR magnetic resonance imaging OR MRI OR radiogra* OR roentgenogra* OR skiagra* OR ultraso* OR NMR OR nuclear magnetic resona nce)<br>*Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=1956-2020* |
| 4 | #1 AND #2 AND #3<br>*Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=1956-2020* |

## PubMed search (date limit from 1900/1/1 to 2020/12/31)

((("adolescences"[All Fields] OR "adolescency"[All Fields] OR "adolescent"[MeSH Terms] OR "adolescent"[All Fields] OR "adolescence"[All Fields] OR "adolescents"[All Fields] OR "adolescent s"[All Fields]) AND ("idiopathic"[All Fields] OR "idiopathically"[All Fields] OR "idiopathics"[All Fields]) AND ("scoliosis"[MeSH Terms] OR "scoliosis"[All Fields] OR "scolioses"[All Fields])) OR (("adolescences"[All Fields] OR "adolescency"[All Fields] OR "adolescent"[MeSH Terms] OR "adolescent"[All Fields] OR "adolescence"[All Fields] OR "adolescents"[All Fields] OR "adolescent s"[All Fields]) AND ("scoliosis"[MeSH Terms] OR "scoliosis"[All Fields] OR "scolioses"[All Fields]))) AND ("disease progression"[MeSH Terms] OR ("disease"[All Fields] AND "progression"[All Fields]) OR "disease progression"[All Fields] OR ("disease"[All Fields] AND "course"[All Fields]) OR "disease course"[All Fields] OR ("disease progression"[MeSH Terms] OR ("disease"[All Fields] AND "progression"[All Fields]) OR "disease progression"[All Fields] OR ("disease"[All Fields] AND "exacerbation"[All Fields]) OR "disease exacerbation"[All Fields]) OR ("treatment outcome"[MeSH Terms] OR ("treatment"[All Fields] AND "outcome"[All Fields]) OR "treatment outcome"[All Fields]) OR (("ambulatory care facilities"[MeSH Terms] OR ("ambulatory"[All Fields] AND "care"[All Fields] AND "facilities"[All Fields]) OR "ambulatory care facilities"[All Fields] OR "clinic"[All Fields] OR "clinic s"[All Fields] OR "clinical"[All Fields] OR "clinically"[All Fields] OR "clinicals"[All Fields] OR "clinics"[All Fields]) AND ("outcome"[All Fields] OR "outcomes"[All Fields])) OR ("prognosis"[MeSH Terms] OR "prognosis"[All Fields] OR "prognoses"[All Fields]) OR ("disease progression"[MeSH Terms] OR ("disease"[All Fields] AND "progression"[All Fields]) OR "disease progression"[All Fields])) AND ("diagnostic imaging"[MeSH Subheading] OR ("diagnostic"[All Fields] AND "imaging"[All Fields]) OR "diagnostic imaging"[All Fields] OR "radiography"[All Fields] OR "radiography"[MeSH Terms] OR "radiographies"[All Fields] OR "radiographys"[All Fields] OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields]) OR ("diagnostic imaging"[MeSH Subheading] OR ("diagnostic"[All Fields] AND "imaging"[All Fields]) OR "diagnostic imaging"[All Fields] OR "ultrasonography"[All Fields] OR "ultrasonography"[MeSH Terms] OR "ultrasonographies"[All Fields]) OR ("magnetic resonance spectroscopy"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "spectroscopy"[All Fields]) OR "magnetic resonance spectroscopy"[All Fields] OR ("nuclear"[All Fields] AND "magnetic"[All Fields] AND "resonance"[All Fields]) OR "nuclear magnetic resonance"[All Fields] OR "magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("nuclear"[All Fields] AND "magnetic"[All Fields] AND "resonance"[All Fields])) OR ("diagnostic imaging"[MeSH Subheading] OR ("diagnostic"[All Fields] AND "imaging"[All Fields]) OR "diagnostic imaging"[All Fields] OR "echography"[All Fields] OR "ultrasonography"[MeSH Terms] OR "ultrasonography"[All Fields] OR "echographies"[All Fields]) OR ("image"[All Fields] OR "image s"[All Fields] OR "imaged"[All Fields] OR "imager"[All Fields] OR "imager s"[All Fields] OR "imagers"[All Fields] OR "images"[All Fields] OR "imaging"[All Fields] OR "imaging s"[All Fields] OR "imagings"[All Fields]) OR ("diagnostic imaging"[MeSH Subheading] OR ("diagnostic"[All Fields] AND "imaging"[All Fields]) OR "diagnostic imaging"[All Fields] OR "x ray"[All Fields] OR "x rays"[MeSH Terms] OR "x rays"[All Fields]) OR ("diagnostic imaging"[MeSH Subheading] OR ("diagnostic"[All Fields] AND "imaging"[All Fields]) OR "diagnostic imaging"[All Fields] OR "roentgenography"[All Fields] OR "radiography"[MeSH Terms] OR "radiography"[All Fields]) OR "Skiagraphy"[All Fields] OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR "mri"[All Fields]))

**Table i.** Summary of study characteristics.

| Study | Year | Study design | Sample size | Inclusion criteria | Morphological predictors found | Risk of bias | Phase of inquiry | Level of evidence |
|---|---|---|---|---|---|---|---|---|
| Catanzano et al[1] | 2020 | RCS | 43 | 1) Bracing<br>2) Reached skeletal maturity (Risser 4 or 5)<br>3) Self-reported compliance of 16 to 18 hrs | 1) Pelvic incidence<br>2) Sacral slope<br>3) Pelvic tilt<br>4) Lumbar lordosis | Moderate | Exploratory | Prognostic level III |
| Cheung and Cheung[2] | 2020 | RCS | 586 | 1) Aged 10 yrs or above, presented with Risser stage 0 to 2<br>2) With a major curve of 25° to 40°<br>3) Had not previously been under treatment<br>4) Compliance < 16 hrs a day<br>5) Underarm bracing | 1) Thoracic curve<br>2) Pre-brace Cobb angle<br>3) Flexibility<br>4) Correction rate | Low | Confirmatory for flexibility; exploratory for apical ratio | Prognostic level III |
| Cheung et al[3] | 2020 | RCS | 586 | Underwent underarm TLSO bracing according to the SRS criteria:<br>aged 10 to 14 yrs, major curve magnitude 25° to 40°, Risser Stage 0 to 2, less than one yr post-menarche, and no previous treatment | 1) Supine Cobb angle<br>2) Flexibility<br>3) Correction rate<br>4) Apical ratio | Low | Exploratory | Prognostic level III |
| Courvoisier et al[4] | 2013 | Not specified | 78 | 1) AIS with Cobb angle > 4° and < 25° | 1) Apical axial rotation<br>2) | Moderate | Exploratory | Prognostic level III |

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| | | | | | Intervertebral axial rotation at the upper and lower neutral zone<br>3) Torsion index | | | |
| Dolan et al[5] | 2019 | Review of RCT data | 115 | 1) Not braced<br>2) Cobb angle progressing to > 45°, fusion surgery, or reached skeletal maturity (SMS > 7 and/or Risser > 4) during the trial. | 1) Curve type (presence of thoracic apex)<br>2) Initial Cobb angle | Low | Confirmatory | Prognostic level II |
| Guo et al[6] | 2012 | RCS | 60 | 1) Single thoracic curve with apex at or above T8 (Cobb angle 25° to 40°)<br>2) Milwaukee brace<br>3) aged 10 to 15 yrs, Risser sign 0 to 2, either pre-menarche or less than one yr post-menarche<br>4) compliance ratio ≥ 75 % | 1) Pelvic tilt<br>2) T1 spinopelvic inclination<br>3) T9 spinopelvic inclination | High | Exploratory | Prognostic level III |
| Karol[7] | 2001 | ACS | 112 | 1) Braced male AIS patients | 1) Cobb angle | High | Exploratory | Prognostic level III |
| Katz and Durrani[8] | 2001 | RCS | 51 | 1) Be at least 10 yrs of age, Risser sign 0 to 2, curve size between 36° and 45°<br>2) Boston brace | 1) EVA type<br>2) In-brace correction of Cobb angle in double curves<br>3) In-brace correction of apical vertebral | Moderate | Exploratory | Prognostic level III |

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| | | | | | rotation (lumbar)<br>4) In-brace correction of apical vertebral translation (lumbar)<br>5) LPR angle<br>6) In brace percentage change RVACx and RVACv | | | |
| Kwan et al[9] | 2021 | PCS | 46 | 1) Age of 10 to 15 yrs, < 1 year post-menarche, Cobb angle of 25° to 40°<br>2) Skeletal immaturity (defined as 0 to 2 on the Risser scale or R6 U5 or below on Distal Radius Ulnar Classification)<br>3) Compliance > 12.9 hrs | 1) Supine flexibility<br>2) Cobb angle reduction velocity at one yr<br>3) Immediate in-brace correction rate<br>4) Pre-brace AVR<br>5) AVR correction velocity at one yr<br>6) Upper intervertebral axial rotation at one yr | Low | Exploratory | Prognostic level II |

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| Labrom et al[10] | 2020 | PCS | 30 | 1) Right-sided thoracic major curve<br>2) Age > 10 yrs. Risser grade ≤ 2, pre-menarche or within 6 mths of menarche | Greater disparity between apical VB and IVD wedging | High | Exploratory | Prognostic level II |
| Lara et al[11] | 2017 | RCS | 223 | 1) African-American<br>2) Age 10 to 18 yrs old at presentation | 1) Initial Cobb angle<br>2) Curve type | Moderate | Exploratory | Prognostic level III |
| Lee et al[12] | 2012 | RCS | 2,308 | 1) Untreated AIS<br>2) Age ≥ 10 yrs, Risser sign ≤ 2, Cobb angle < 30° | Initial Cobb angle | Low | Confirmatory | Prognostic level III |
| Mao et al[13] | 2016 | RCS | 95 | 1) Age 10 to 14 yrs, Risser stage 0 to 2, pre-menarche or less than 1 yr post-menarche, Cobb angle 20° to 40°, female sex<br>3) Boston brace or Milwaukee brace<br>4) Compliance > 75% | 1) ICR<br>2) Initial Cobb ARV<br>3) Initial cobb angle | Moderate | Confirmatory | Prognostic level III |
| Modi et al[14] | 2009 | RCS | 113 | 1) Thoracic or thoraco-lumbar curve, double curves with major thoracic curve<br>2) Cobb angle > 40° | 1) RVACx and RVAD at final follow-up<br>2) Difference between final and pre-brace RVACx | Moderate | Exploratory | Prognostic level III |
| Nault et al[15] | 2014 | PCS | 133 | 1) Cobb angle 11° to 40°<br>2) Risser sign of 0 or 1 | 1) Angle of plane of maximal curvature | High | Exploratory | Prognostic level II |

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| | | | | | 2) Kyphosis<br>3) AVR<br>4) Torsion<br>5) Slenderness of the spine | | | |
| Ohashi et al[16] | 2018 | RCS | 56 | 1) AIS with a TL/L curve crossing the CSVL at skeletal maturity<br>2) Aged ≥ 30 yrs at the time of the survey | 1) AVT<br>2) L3 tilt<br>3) Apex score | Moderate | Exploratory | Prognostic level III |
| Ohashi et al[17] | 2019 | RCS | 51 | 1) Right thoracic curve with compensatory lumbar curve not crossing the CSVL<br>2) Age ≥ 30 yrs at the time of the survey | 1) Lumbar modifier B | Moderate | Exploratory | Prognostic level III |
| Ohrt-Nissen et al[18] | 2016 | RCS | 63 | 1) Age > 10 yrs, Cobb angle 25° to 40° and Risser ≤ 2 | 1) Flexibility<br>2) Nash-Moe rotation<br>3) Thoracic curve | Moderate | Confirmatory for flexibility; exploratory for rotation | Prognostic level III |
| Pasha[19] | 2019 | RCS | 45 | 1) Apex at or above T10/T11 disc<br>2) Compliance > 16 hrs | 1) In-brace lordosis<br>2) In-brace thoracic Cobb angle<br>3) Pre-brace lordosis + in-brace kyphosis<br>4) Pre-brace lordosis + sagittal type 2 | Moderate | Exploratory | Prognostic level III |

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| | | | | | 5) Pre-brace thoracic AVR + ribcage type 2 | | | |
| Shi et al[20] | 2016 | RCS | 200 | 1) Female<br>2) Age 10 to 14 yrs, < 1 year post-menarche, Risser 0 to 2, Cobb angle 20° to 40° | 1) Cobb angle at brace weaning and initial visit | Moderate | Exploratory | Prognostic level III |
| Sun et al[21] | 2016 | RCS | 48 | 1) Female<br>2) Major thoracic curve, age 9 to 12 yrs, premenarchal with Risser 0, Cobb angle 20° to 40°<br>3) Milwaukee brace<br>4) > 90% compliance to the recommended 22 hrs bracing | 1) RVAD at brace initiation and each follow-up<br>2) CRVA at brace initiation and each follow-up | High | Exploratory | Prognostic level III |
| Tan et al[22] | 2009 | PCS | 186 | AIS patients who were skeletally immature at the beginning of the study | Initial Cobb angle | Moderate | Confirmatory | Prognostic level II |
| Thompson et al[23] | 2017 | Review of RCT data | 168 | Risser stage 0 to 2, < 1 yr post-menarche, Cobb angle 25° to 45° | 1) Curve type (main thoracic vs main lumbar)<br>2) Change of curve type during bracing | Low | Confirmatory | Prognostic level III |
| Upadhyay et al[24] | 1995 | RCS | 85 | Cobb angle 20° to 45°, Risser stage 3 or less | Increase/decrease of vertebral rotation and cobb angle in brace | Moderate | Exploratory | Prognostic level III |

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| | | | | | compared to baseline out of brace radiograph | | | |
| Ylikoski[25] | 2005 | RCS | 535 | 1) Untreated adolescent idiopathic scoliosis<br>2) No other diseases apart from a possible spondylolysis and spondylolisthesis | 1) Thoracic kyphosis<br>2) Cobb angle | High | Exploratory | Prognostic level III |
| Zhang et al[26] | 2014 | RCS | 89 | 1) Age > 10 yrs, Cobb angle < 45°<br>2) Equal lower limbs and no sign of degenerative disorders | 1) Cobb angle of primary curve<br>2) Nash-Moe rotation | High | Exploratory | Prognostic level III |

AIS, adolescent idiopathic scoliosis; ARV, angle reduction velocity; AVT, apical vertebral translation; CRVA, convex rib vertebral angle; CSVL, central sacral vertical line; EVA, end vertebral angle; ICR, initial correction rate; LPR, lumbar pelvic relationship; PCS, prospective cohort study; RCS, retrospective cohort study; RCT, randomized controlled trials; RVACv, rib vertebra angle on the concave side; RVACx, rib vertebra angle on the convex side; RVAD, rib vertebra angle difference; SMS, skeletal maturity stage; SRS, Scoliosis Research Society; TLSO, thoracolumbosacral orthosis.

**Table ii.** Quality in Prognostic Studies risk of bias.

| Study | Study participation | Study attrition* | Prognostic factor measurement | Outcome measurement | Study confounding | Statistical analysis and reporting | Overall risk of bias |
|---|---|---|---|---|---|---|---|
| Catanzano et al[1] | Moderate | N/A | Low | Low | Moderate | Low | Moderate |
| Cheung and Cheung[2] | Moderate | N/A | Low | Low | Moderate | Low | Low |
| Cheung et al[3] | Moderate | N/A | Low | Low | Moderate | Low | Low |
| Courvoisier et al[4] | Moderate | Moderate | Low | Low | Moderate | Moderate | Moderate |
| Dolan et al[5] | Low | N/A | Low | Low | Low | Low | Low |
| Guo et al[6] | Moderate | N/A | Low | Low | High | High | High |

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| Karol[7] | Moderate | Moderate | Low | Low | High | Low | High |
| Katz and Durrani[8] | Moderate | N/A | Low | Low | High | Low | Moderate |
| Kwan et al[9] | Low | Low | Low | Low | Low | Low | Low |
| Labrom et al[10] | Moderate | Moderate | Low | Low | High | High | High |
| Lara et al[11] | High | N/A | Moderate | Moderate | Low | Low | Moderate |
| Lee et al[12] | Moderate | N/A | Low | Low | Low | Low | Low |
| Mao et al[13] | Moderate | N/A | Low | Low | Moderate | Moderate | Moderate |
| Modi et al[14] | Moderate | N/A | Low | Low | High | High | Moderate |
| Nault et al[15] | Moderate | High | Low | Low | High | High | High |
| Ohashi et al[16] | Low | Moderate | Moderate | Moderate | Low | Moderate | Moderate |
| Ohashi et al[17] | Moderate | Moderate | Low | Low | Moderate | Low | Moderate |
| Ohrt-Nissen et al[18] | Moderate | N/A | Low | Low | Moderate | Low | Moderate |
| Pasha[19] | Moderate | N/A | Low | Low | Moderate | Low | Moderate |
| Shi et al[20] | Moderate | N/A | Low | Low | High | Low | Moderate |
| Sun et al[21] | Moderate | N/A | Moderate | Low | High | High | High |
| Tan et al[22] | Low | Moderate | Moderate | Low | Moderate | Low | Moderate |
| Thompson et al[23] | Low | N/A | Low | Low | Moderate | Low | Low |
| Upadhyay et al[24] | Moderate | N/A | Low | Low | High | Low | Moderate |
| Ylikoski[25] | Moderate | N/A | Moderate | Low | High | High | High |
| Zhang et al[26] | Moderate | N/A | Moderate | Low | High | High | High |

*For retrospective studies, study attrition is not applicable (N/A).

**Table iii.** Summary of key findings and statistical methods for predictors with sufficient evidence.

| Predictors | Population | Study | Key findings | Strength of evidence |
|---|---|---|---|---|
| Initial Cobb angle | Braced | Zhang et al[26] | Initial Cobb angle > 35° predicted progression > 5° (OR 13.691; 95% CI 6.33 to 29.6; $p = 0.001$), adjusted for apical vertebral rotation, Risser sign and spinal length growth velocity. | Low |
| | | Karol[7] | Initial Cobb angle predicted curve progression to 50° or surgery ($p < 0.0001$) but not progression ≥ 6°. | |

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| | | Cheung et al[2,3] | Initial Cobb angle was associated with curve progression ≥ 5° in univariate analysis ($p = 0.01$) and multivariable logistic regression (OR = 1.065; 95% CI 1.01 to 1.123; $p = 0.02$). Initial Cobb angle did not differentiate the progressed, stable and regressed groups of patients in univariate analysis. | |
| | | Guo et al[6] | Initial Cobb angle was not significantly associated with progression ≥ 6°. | |
| | | Sun et al[21] | Groups with initial Cobb angle between 20° to 29° and 30° to 40° did not show significant difference in the proportion of patients showing progression ≥ 6°. | |
| | | Catanzano et al[1] | Initial Cobb angle was not significantly associated with incidence of surgery ($p = 0.457$). | |
| | | Katz and Durrani[8] | Initial Cobb angle was not significantly associated with progression ≥ 5° ($p = 0.35$). | |
| | | Mao et al[13] | Initial Cobb angle was not significantly associated with progression ≥ 6° ($p = 0.263$). | |
| | | Ohrt-Nissen et al[18] | Initial Cobb angle was not significantly associated with progression ≥ 6° in univariate analysis ($p = 0.396$) and multivariable logistic regression (OR 0.99; 95% CI 0.83 to 1.18) adjusted for menarchal status, age, and flexibility. | |
| | Unbraced | Ylikoski[25] | Groups with initial Cobb angle < 15° and 15 to 19° had significantly different progression velocity ($p < 0.05$). | High |
| | | Tan et al[22] | ROC curve analysis identified 25° as the ideal cut-off for initial Cobb angle. Initial Cobb angle > 25° was significantly associated with progression to 30° in both univariate (OR 24.6; 95% CI 9.9 to 60.6; $p < 0.001$) and multivariable logistic regression (OR 27.5; 95% CI 10.2 to 73.9; $p < 0.001$). | |
| | | Lara et al[11] | Initial Cobb angle was significantly associated with progression > 5° (OR 1.03; 95% CI 1.01 to 1.04; $p = 0.002$) in a multivariable logistic regression adjusting for age, sex, and curve type. | |

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| | | Dolan et al[5] | Initial Cobb angle significantly predicted progression to 45° at maturity with odds ratio 1.28 (95% CI 1.15 to 1.43) adjusted for simplified skeletal maturity score and presence of thoracic apices. | |
| | | Lee et al[12] | Initial Cobb angle was significantly associated with progression to 30° in univariate survival analysis (hazard ratio = 1.18; 95% CI 1.16 to 1.21; $p < 0.001$) but was not significant in multivariable survival analysis (hazard ratio = 0.84; 95% CI 0.69 to 1.03, $p = 0.095$). Initial Cobb angle was also shown to interact with age (hazard ratio = 1.03; 95% CI 1.01 to 1.05; $p < 0.001$).<br>Classification and regression tree analysis found that risk groups categorized by Cobb angle and a few other factors including age, menarchal status, and height showed hazard ratios significantly different from each other in pairwise comparison ($p < 0.01$). Patients with Cobb angle > 25.8° had a hazard ratio of 8.8 compared to patients with Cobb angle < 18.4°. | |
| | | Nault et al[15] | Neither 2D nor 3D Cobb angle was significantly associated with progression ≥ 6° ($p = 0.2$ for both 2D and 3D Cobb angle). | |
| | Beyond maturity | Shi et al[20] | Both Cobb angle at brace initiation and Cobb angle at brace weaning were significantly associated with curve progression to 45° two years after skeletal maturity ($p < 0.05$ for both predictors). A larger Cobb angle at skeletal maturity was also predictive of curve progression of more than 5° after skeletal maturity ($p = 0.033$). | Inconclusive |
| Curve type (thoracic curves) | Braced | Thompson et al[23] | mLenke curve types did not significantly predict progression to surgery (50°) ($p = 0.0866$) but main thoracic curve did ($p = 0.0277$), even after adjusting for brace compliance ($p = 0.0239$). Thoracic curves did not predict progression when | Low |

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| | | | stratified by Risser stage (p = 0.231 for Risser 0 group and p = 0.542 for Risser 1 and 2 group). A change in curve type during bracing was significantly associated with a lower rate of surgery or progression to 50° (p = 0.0383). | |
| | | Ohrt-Nissen et al[18] | Thoracic curves were significantly associated with progression ≥ 6° in univariate linear regression (coefficient = 13.66; 95% CI 4.2 to 22.5; p = 0.005). The curve type distributions (categorized into thoracic, thoracolumbar, lumbar, and double major curves) between the progressed and stable groups were significantly different (p = 0.032). | |
| | | Cheung and Cheung[2] | Thoracic curves were significantly associated with progression > 5° in both univariate (OR 3.32; 95% CI 2.35 to 4.69; p < 0.001) and multivariable logistic regression (OR 1.635; 95% CI 1.076 to 2.483; p = 0.022). | |
| | | Katz and Durrani[8] | Curve type did not predict progression ≥ 5° (p = 0.615) | |
| | | Zhang et al[26] | Curve type was not selected as a predictor for progression > 5° in the multivariable logistic regression. | |
| | | Kwan et al[9] | Thoracic curves were not associated with progression > 5° in both univariate analysis (p = 0.615) and multivariable logistic regression (OR 1.4; 95% CI 0.39 to 5.027; p = 0.606). | |
| | Unbraced | Dolan et al[5] | The presence of one or more thoracic apices predicted curve progression to 45° at skeletal maturity in a multivariable logistic regression (OR 4.09; 95% CI 0.88 to 18.96; p = 0.07). | Moderate |
| | | Lara et al[11] | Curve type categorized into single thoracic, single lumbar, double thoracic, double lumbar, and thoracolumbar was not predictive of progression to 50° or incidence of surgery (p < 0.05 for all) in multivariable logistic regression adjusting for age, sex, and curve magnitude. | |
| | Beyond maturity | Ohashi et al[16] | A more cranially located curve apex predicted progression 25 years after skeletal maturity (p = 0.025) in univariate analysis. | Inconclusive |

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| Flexibility | Braced | Cheung et al[2,3] | Higher flexibility predicted lower risk of curve progression ≥ 5° in both univariate (OR 0.949; 95% CI 0.94 to 0.96; $p < 0.001$) and multivariable logistic regression (OR 0.958; 95% CI 0.943 to 0.974; $p < 0.001$), adjusted for curve type, Cobb angle, flexibility, etc. | High |
| | | Kwan et al[9] | Supine flexibility was associated with the magnitude of curve progression in a univariate linear regression ($p = 0.032$) and statistical significance remained when fitted in a multivariable logistic regression (OR 0.962; 95% CI 0.929 to 0.999; $p = 0.042$). | |
| | | Ohrt-Nissen et al[18] | Flexibility was different between progressed and stable patients in both univariate analysis ($p < 0.001$) and multivariable logistic regression (OR 0.95; 95% CI 0.90 to 0.98), adjusted for Cobb angle, age and menarchal status. | |
| In-brace correction | Braced | Cheung et al[2,3] | In-brace correction was significantly associated with curve progression ≥ 5° in both univariate (OR 0.949; 95% CI 0.94 to 0.96; $p < 0.001$) and multivariable logistic regressions (OR 0.979; 95% CI 0.966 to 0.991; $p = 0.001$). | Moderate |
| | | Kwan et al[9] | In-brace correction was significantly associated with curve progression ≥ 5° in both univariate ($p = 0.009$) and multivariable logistic regressions (OR 0.966; 95% CI 0.938 to 0.994, $p = 0.019$). | |
| | | Katz and Durrani[8] | In-brace correction was predictive of progression > 5° in double curves in univariate analysis ($p = 0.02$). | |
| | | Karol[7] | In-brace correction was not associated with progression ≥ 6° in univariate analysis ($p < 0.05$). | |
| | | Ohrt-Nissen et al[18] | In-brace correction was significantly different between progression and stable groups by the 6° margin ($p = 0.009$). | |
| | | Pasha[19] | In-brace thoracic Cobb angle was predictive of curve progression in a multivariable analysis by LASSO regression ($p = 0.025$). | |

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| | | Mao et al[13] | Correction rate, defined as correction between the first two visits, and initial Cobb angle reduction velocity, defined as Cobb angle reduction velocity between the first two visits, were significantly predictive of brace outcome. Initial Cobb angle reduction velocity was found to be superior to correction rate in the prediction of outcome. | |

CI, confidence interval; LASSO, least absolute shrinkage and selection operator; OR, odds ratio; ROC, receiver operating characteristic.

**Table iv.** Summary of key findings and statistical methods for predictors with less sufficient evidence.

| Predictors | Population | Study | Key findings | Strength of evidence |
|---|---|---|---|---|
| Rib morphology | Braced | Sun et al[21] | Rib vertebral angle difference (RVAD) > 20° and rib vertebral angle on the convex side (RVACx) < 68° predicted curve progression $\geq$ 6°. RVAD and RVACx also differed significantly between patients from the stable and progressed groups at follow-ups at 0, 6, 12, 24, 36 months, and at final follow-up in a cohort where initial Cobb angle did not significantly predict progression. | Very low |
| | | Katz and Durrani[8] | The in-brace correction of RVACx (p = 0.005) and rib vertebra angle on the concave side (RVACv) (p = 0.005) were significantly different between the progressed and stable groups by the 5° margin. | |
| | | Modi et al[14] | RVAD (p = 0.269). RVACx (p = 0.492) and RVACv (p = 0.693) were not significantly different between progressed and stable groups but final RVAD (p = 0.0079) and RVACx (p = 0.0002) were significantly different. | |
| | | Pasha[19] | A combination of high thoracic apical vertebral rotation and an RVACx > 60° was significantly associated with curve progression by multivariable LASSO regression (p = 0.04). | |
| AVR | Braced | Kwan et al[9] | Pre-brace AVR was also significantly predictive of progression $\geq$ 5° in multivariable logistic regression (OR 1.063; 95% CI 1.000 to 1.131; p = 0.049).<br>AVR correction velocity in 1 year was predictive of progression $\geq$ 5° in multivariable logistic regression (OR 1.19; 95% CI 1.021 to 1.38; p = 0.026). | Low |
| | | Zhang et al[26] | Patients with Nash-Moe rotation beyond grade III predicted progression > 5° (OR 16.134; 95% CI 6.31 to 41.2; p = 0.003) in a multivariable logistic regression. | |

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| | | Ohrt-Nissen et al[18] | Nash-Moe rotation predicted progression ≥ 6° in univariate analysis ($p = 0.012$) | |
| | | Upadhyay et al[24] | A reduction of both the Perdriolle rotation and Cobb angle after application of brace predicted non-progression and an increase in both after application of brace predicts curve progression ≥ 5° ($p < 0.05$). | |
| | Unbraced | Courvoisier et al[4] | AVR was predictive of curve progression in a stepwise logistic regression (OR 1.39; $p = 0.006$). K-means cluster analysis using AVR and three other predictors as parameters yielded clusters with significantly different proportions of progressed patients, independent of curve type. | Inconclusive |
| | | Nault et al[15] | Apical intervertebral rotation (the axial rotation of the apical vertebral relative to its adjacent vertebrae) was predictive of curve progression ≥ 6° in univariate analysis ($p = 0.006$) | |
| PT | Braced | Catanzano et al[1] | Greater PT was significantly associated with lower incidence of surgery in univariate analysis ($p = 0.003$). The ideal cut-off for PT is 8.5° by ROC curve analysis and PT greater than 8.5° was significantly associated with lower incidence of surgery (OR 0.7; 95% CI 0.54 to 0.91; $p = 0.009$), adjusted for Cobb angle and Risser stage. | Very low |
| | | Guo et al[6] | Greater PT was significantly associated with lower risk of progression ≥ 6° in univariate analysis ($p < 0.01$) and in multivariable regression analysis adjusted for Cobb angle and Risser stage ($p < 0.01$). | |

AVR, apical vertebral rotation; CI, confidence interval; LASSO, least absolute shrinkage and selection operator; OR, odds ratio; PT, pelvic tilt; ROC, receiver operating characteristic; RVACv; rib vertebra angle on the concave side; RVACx, rib vertebra angle on the convex side; RVAD, rib vertebra angle difference.

**Table v.** Summary of key findings and statistical methods for predictors with inconclusive evidence.

| Predictors | Population | Study | Key findings | Strength of evidence |
|---|---|---|---|---|
| Torsion | Braced | Kwan et al[9] | Torsion at one year of bracing was not significantly correlated with curve progression $\geq$ 5° in a multivariable analysis (OR = 0.592; 95% CI 0.331 to 1.059; p = 0.077). | Inconclusive |
| | Unbraced | Courvoisier et al[4] | Torsion was predictive of curve progression in a stepwise logistic regression (OR = 1.43; p = 0.05). K-means cluster analysis using torsion and three other predictors as parameters yielded clusters with significantly different proportions of progressed patients, independent of curve type. | |
| | | Nault et al[15] | Torsion was associated with curve progression $\geq$ 6° in univariate analysis (p = 0.02). | |
| Vertebral slenderness | Mixed braced and unbraced | Nault et al[15] | Greater T6 width and depth slenderness, T12 depth slenderness, L4 width and depth slenderness and T1-T5 depth and width slenderness were all associated with lower risk of progression $\geq$ 6° (p < 0.05 for all predictors) in univariate analysis. | Inconclusive |
| Angle of plane of maximal curvature | Mixed braced and unbraced | Nault et al[15] | Angle of plane of maximal curvature was associated with progression $\geq$ 6° (p = 0.001). | Inconclusive |
| Intervertebral rotation at the upper and lower junctions of the curve | Braced | Kwan et al[9] | Upper IAR at one year of bracing was associated with progression $\geq$ 5° (OR = 1.22; 95% CI 1.01 to 1.47; p = 0.044) in a multivariable logistic regression, and lower IAR were not found to be significant in multivariable analysis (OR = 0.87; 95% CI 0.71 to 1.067; p = 0.183). | Inconclusive |
| | Unbraced | Courvoisier et al[4] | Intervertebral axial rotation at the upper and lower junctions of the curve was predictive of curve progression in a stepwise logistic | |

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| | | | regression (OR = 1.35; $p = 0.04$ for intervertebral rotation at the upper end; OR = 0.7; $p = 0.03$ for intervertebral rotation at the lower end). K-means cluster analysis using torsion and two other predictors as parameters yielded clusters with significantly different proportions of progressed patients, independent of curve type. | |
| | | Nault et al[15] | Intervertebral rotation at the upper and lower junctions of the curve was not significantly associated with progression ≥ 6°. | |
| Pelvic incidence | Braced | Catanzano et al[1] | Greater pelvic incidence was significantly associated with lower incidence of surgery in univariate analysis ($p < 0.001$). The ideal cut-off for pelvic incidence was 47.2° by ROC curve analysis and PI greater than 47.2° was significantly associated with lower incidence of surgery (OR = 0.68; 95% CI 0.55 to 0.85; $p < 0.001$), adjusted for Cobb angle and Risser stage. | Inconclusive |
| | | Guo et al[6] | Pelvic incidence was not significantly associated with progression ≥6° in univariate analysis ($p > 0.05$). | |
| Sacral slope | Braced | Catanzano et al[1] | Greater sacral slope was significantly associated with lower incidence of surgery in univariate analysis ($p = 0.003$). The ideal cut-off for sacral slope is 43° by ROC curve analysis and SS greater than 43° was significantly associated with lower incidence of surgery (OR = 0.8; 95% CI 0.68 to 0.94; $p = 0.006$), adjusted for Cobb angle and Risser stage. | Inconclusive |
| | | Guo et al[6] | Sacral slope was not significantly associated with progression ≥ 6° in univariate analysis ($p > 0.05$). | |
| Thoracic kyphosis | Braced | Catanzano et al[1] | Thoracic kyphosis was not significantly associated with incidence of surgery in univariate analysis ($p = 0.466$). | Inconclusive |
| | Unbraced | Ylikoski[25] | Patients with greater thoracic kyphosis had a lower yearly curve progression rate for both major and minor curves in univariate analysis ($p < 0.05$). | Inconclusive |
| | | Nault et al[15] | Thoracic kyphosis was predictive of curve progression ≥ 6° ($p = 0.02$) in univariate analysis. | |

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| Lumbar lordosis | Braced | Catanzano et al[1] | Lumbar lordosis was significantly associated with incidence of surgery in univariate analysis ($p = 0.034$). | Inconclusive |
| | | Guo et al[6] | Lumbar lordosis was not significantly associated with incidence of surgery in univariate analysis ($p > 0.05$). | |
| | | Pasha[19] | In-brace lordosis ($p = 0.027$), pre-brace lordosis together with in-brace kyphosis ($p = 0.046$) and pre-brace lordosis with RVACx > 60° ($p = 0.031$) were found to be significant predictors of curve progression in LASSO regression. | |
| | | Nault et al[15] | Lumbar lordosis was not significantly associated with progression > 5° in a mixed cohort of braced and unbraced patients. | |
| T1 and T9 spinopelvic inclination | Braced | Catanzano et al[1] | T1 ($p = 0.631$) and T9 spinopelvic inclinations ($p = 0.722$) were not predictive of incidence of surgery in univariate analysis. | Inconclusive |
| | | Guo et al[6] | T1 and T9 spinopelvic inclinations were significantly associated with lower risk of progression ≥ 6° in univariate analysis ($p < 0.05$ for both predictors) and in multivariable regression analysis adjusted for Cobb angle and Risser stage ($p < 0.05$ for both predictors). | |
| Wedging | Braced | Cheung et al[2,3] | Pre-brace apical ratio did not predict curve progression ≥ 5° (OR = 0.541; 95% CI 0.05 to 5.77; $p = 0.611$) in univariate analysis. An increase in apical ratio during bracing predicted higher rate of progression (OR = 1.24; 95% CI 1.19 to 1.31; $p < 0.01$) and lower rate of regression (OR = 0.84; 95% CI 0.80 to 0.87; $p < 0.01$) in multivariable logistic regression models. | Inconclusive |
| | Unbraced | Labrom et al[10] | Greater disparity between vertebral body wedging and intervertebral disc wedging predicted curve progression ($p = 0.03$) in univariate analysis. | Inconclusive |

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| | | Nault et al[15] | Neither 3D apical vertebral wedging nor 3D apical disc wedging predicted curve progression ($p > 0.05$). | |
| Apical vertebral translation | Braced and unbraced | Katz and Durrani[8] | In-brace correction of apical vertebral translation in lumbar curves of double curves was significantly associated with curve progression ($p = 0.05$) in univariate analysis. | Inconclusi ve |
| | Beyond maturity | Ohashi et al[16] | Greater apical vertebral translation predicted greater progression 25 years after skeletal maturity in univariate analysis ($p = 0.016$) | Inconclusi ve |
| Lumbar-pelvic relation | Braced and unbraced | Katz and Durrani[8] | Lumbopelvic angle in patients with a double curve where the thoracic curve exceeded 36° was associated with curve progression ($p = 0.006$). | Inconclusi ve |
| EVA type | Braced and unbraced | Katz and Durrani[8] | EVA types were significantly associated with curve progression in univariate analysis ($p = 0.04$) | Inconclusi ve |
| L3 tilt | Beyond maturity | Ohashi et al[16] | L3 tilt predicted progression 25 years after skeletal maturity in univariate analysis ($p = 0.02$) | Inconclusi ve |
| Lumbar modifier B | Beyond maturity | Ohashi et al[17] | Lumbar modifier B in the Lenke classification system at skeletal maturity predicted greater curve progression of compensatory lumbar curves 25 years after maturity. | Inconclusi ve |

CI, confidence interval; EVA, end-vertebra angle; IAR, intervertebral axial rotation; LASSO, least absolute shrinkage and selection operator; OR, odds ratio; ROC, receiver operating characteristic; RVACx, rib vertebra angle on the convex side; SS, sacral slope.

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