Use of machine learning algorithms in sagittal plane correction in adolescent idiopathic scoliosis surgery

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INTRODUCTION:

Sagittal balance in spinal deformity received increasing focus in recent years. The advent of pedicle screws provided surgeons with a powerful tool that allows for correction in multiple planes. Rod contouring in deformity surgery has been done arbitrarily based on surgeons' preference which resulted in considerable variability. Even with contoured rods there are reports of residual thoracic hypokyphosis in post operative adolescent idiopathic scoliosis (AIS) patients. This thoracic hypokyphosis has resulted in loss of lumbar lordosis (LL), increased incidence of proximal junctional kyphosis (PJK) and distal junctional kyphosis (DJK), increased incidence of lower back pain, and cervical kyphosis. A wide range of values have been reported in literature for ideal thoracic kyphosis (TK). Different methods have been proposed to choose ideal values to "restore" alignment. These include referencing values from the normal population or using individual pelvic parameters to calculate ideal lumbar lordosis (LL), and subsequently thoracic kyphosis (TK). Previous research has shown that machine-learning (ML) algorithms can optimize surgical planning. This study investigates whether ML algorithms can be used to accurately predict compensatory changes in sagittal spinopelvic parameters after all-posterior spinal fusion (PSF) in patients with AIS.

METHODS: Lenke 1-4 adolescent idiopathic scoliosis patients who underwent posterior spinal fusion with patient specific rods and minimum 2-year follow-up were retrospectively reviewed. During preoperative planning, closing and opening wedges were simulated on preoperative radiographs to achieve desired thoracic kyphosis. A machine learning model was used to predict postoperative lumbar lordosis and pelvic tilt. Pre-contoured titanium rods, based off the surgical plan, were utilized during corrective surgery. Standard radiographic measurements as well as Scoliosis Research Society (SRS) - 22 questionaire were obtained preoperatively, 1 year and 2 years postoperatively.

RESULTS:

34 patients from 54 consecutive cases of patients with adolescent idiopathic scoliosis underwent posterior spinal fusion with 6.0mm Titanium patient specific rods. At 2-year follow-up, the median thoracic kyphosis gain was 9.3° vs. preoperative [IQR: -1.9°, 20.5°] (p=.003) and 4.9° vs. predicted [-1.6°, 10.8°] (p<.001). Median differences of postoperative vs. predicted in lumbar lordosis and pelvic tilt were -3.8° [IQR: -10.4°, 1.4°] (p=.006) and -0.1° [IQR: -3.7°, 3.3°] (p=.555) respectively. At 2-year follow-up in the hypokyphotic subgroup (TK <20°) (n=12), median thoracic kyphosis gain was 22.4° vs. preoperative [IQR: 15.6°, 21.2°] (p=.002) and 2.1° vs. predicted [IQR: -2.1°, 8.1°] (p=.239). Median differences of postoperative vs. predicted in lumbar lordosis and pelvic tilt were -3.4° [-9.7°, 0.4°] (p=.083) and 0.5° [IQR: -2.0°, 2.7°] (p=.262) respectively. Among the 30 patients who completed preoperative and postoperative SRS22 assessments at the 12-month and 24-month time points, substantial improvements were observed in the distributions of pain, self-image, and satisfaction levels in comparison to their respective preoperative baselines (p < .05).

DISCUSSION AND CONCLUSION: Machine learning algorithms accurately predicted the compensatory changes in the spinopelvic parameters of the unfused segments after adolescent idiopathic scoliosis surgery in our hypokyphotic subset of patients. Our overcorrection of thoracic kyphosis in the total cohort demonstrates increased postoperative lumbar lordosis when compared to the planned values. Improvement of the machine learning algorithm with more data will allow surgeons to more accurately plan overall sagittal alignment, by adjustment of planned thoracic kyphosis and predicted lumbar lordosis and pelvic tilt, to achieve harmonious balance and allow these findings to be generalized to other patient populations.