

Introduction

Proximal Junctional Kyphosis (PJK) is a prevalent problem following sagittal correction in adult spinal deformity (ASD). Reciprocal changes in cervical lordosis have been demonstrated following thoracolumbar deformity correction, but changes in cervical alignment after PJK have not been investigated. We introduce two novel global sagittal angular parameters, Cervical-Thoracic Pelvic Angle (CTPA) and the T1 Pelvic angle (TPA), that define the relative proportion of cervical and thoracolumbar deformities (Figure 1).

Objective

This study investigates the changes in cervical alignment with the novel parameters, CTPA and the TPA, and established linear measures of deformity such as C2C7 Plumbline (CPL) and C7 SVA following PJK after thoracolumbar deformity correction.

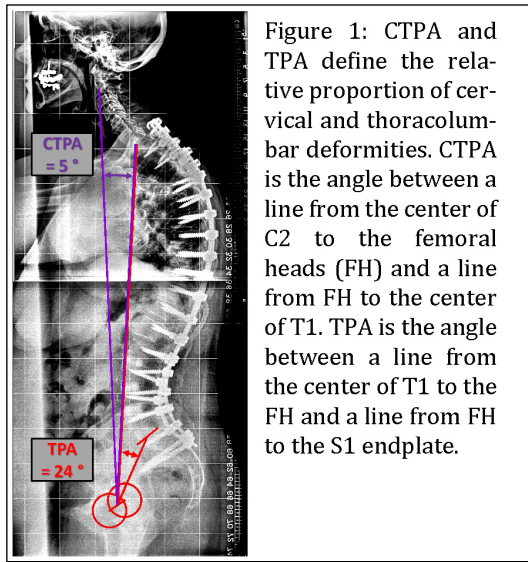
Methods

Multicenter, retrospective, analysis of consecutive ASD patients undergoing PSO with fusion to the pelvis. Inclusion criteria for the study were: age >18 years old, and sagittal deformity requiring PSO. Radiographic evaluation of the spino-pelvic sagittal alignment was performed at baseline and 1 year using Spineview and includes the following parameters

- Thoraco-lumbar parameters: Pelvic Incidence minus Lumbar Lordosis (PI-LL), Pelvic Tilt (PT), Thoracic Kyphosis (TK), Sagittal Vertical Axis (SVA)
- Cervical parameters: Cervical lordosis (CL), Cervical Plumbline (C2C7PL)

- Proximal junctional kyphosis (PJK):
measured from UIV to UIV+2.
- Two novel radiographic parameters:
T1 pelvic angle (TPA) and Cervical-Thoracic Pelvic Angle (CTPA) => see Figure 1

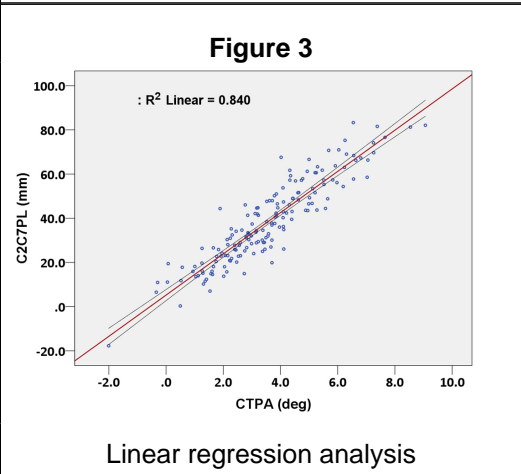
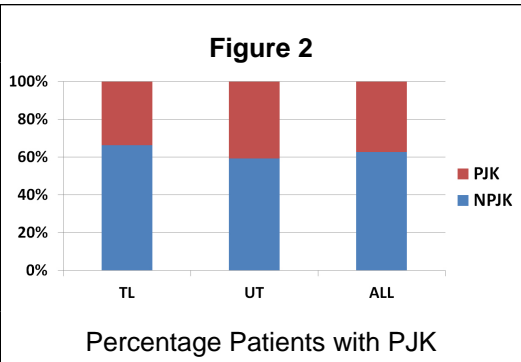
Patients were sub-stratified into upper thoracic (UT) with UIV T6 and above and lower thoracic (LT) with UIV below T6. For each of the UIV group, patients who developed a PJK were compared to those without PJK (NPJK) at 1Y using an unpaired t-test.



Results

166 ASD patients (mean age 59.1, 70.2% Female) met the inclusion criteria. PJK developed in 62 patients (37.3%, Fig. 2). CTPA correlated strongly with C2C7PL as a measure of cervical sagittal balance ($r=0.916$, $p<0.001$). Utilizing a linear regression analysis (R Square = 0.840), a CTPA value of 3.6° was found to correspond to C2C7PL of 4.0 cm (Fig. 3).

There were no significant differences in PJK patients and those without PJK (NPJK) in terms of preoperative thoracolumbar deformity by SVA or TPA, cervical alignment by C2C7PL or CTPA, age, sex and BMI. PJK patients did not differ with NPJK by postoperative thoracolumbar alignment or magnitude of correction.



TL group (n=80)

The comparison between PJK and NPJK (Table 1) revealed that patients with PJK at 1 year had a larger thoracic kyphosis (TK), a smaller Pelvic Tilt (PT), and an over-correction of the lumbar lordosis ($PI - LL < 0^\circ$)

UT group (n=86)

Patients with PJK at 1 year (Table 1) had larger CTPA (4.7° vs 3.6°, $p=0.008$), C2C7PL (4.83 vs 3.92 cm, $p=0.03$), CL (20.1° vs 7.32° $p=0.001$) and T1 Slope (36.0° vs 26.9°, $p=0.003$). UT PJK patients had greater paradoxical changes in their CTPA (1.93° vs 0.64°, $p<0.001$) and C2C7PL (0.75cm vs -0.17cm $p=0.01$) despite similar global corrections by SVA, TPA and PI-LL.

Parameter	TL NPJK	TL PJK	UT NPJK	UT PJK
C2C7PL (mm)	34.5	33.1	39.2	48.3*
CL (°)	8.7	14.4	7.3	20.1*
TPA (°)	21.8	16.6*	18.0	20.5
CTPA (°)	3.1	3.0	3.6	4.7*
T1 Slope (°)	23.9	27.6	26.9	36.0*
TK (°)	34.6	51.8*	39.8	37.7
PI-LL (°)	10.2	-6.6*	2.2	5.4
PT (°)	24.9	19.5*	22.9	26.5
SVA (mm)	45.8	39.9	26.5	22.1

Conclusions

CTPA correlated strongly with C2PL as a measure of cervical sagittal balance. PJK was prevalent, developing in 37.3% of ASD patients undergoing thoracolumbar 3CO. Following 3CO, PJK patients with long fusions to the upper thoracic spine (UT) developed cervical sagittal deformities driven by an increase in T1S leading to an increase in their CPL and CTPA.

Learning Objectives

By the conclusion of this session, participants should be able to: (1) Understand how the novel measures of Cervical-Thoracic Pelvic Angle (CTPA) and T1 Pelvic angle (TPA) define the relative proportion of cervical and thoracolumbar deformities; (2) Appreciate the clinical role and application of the CTPA and TPA radiographic measures.