Partial Vertebrectomies without Instrumented Stabilization During En Bloc Resection of Primary Bronchogenic Carcinomas Invading the Spine: Feasibility Study and Results on Spine Balance

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Partial vertebrectomies without instrumented stabilization during en bloc resection of primary bronchogenic carcinomas invading the spine: feasibility study and results on spine balance

Authors

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Key words

Primary bronchogenic carcinomas, Non-small-cell lung cancers, Lung cancers, Pancoast tumors, Vertebrectomies, Vertebral resection, Spine deformity

Abbreviations and Acronyms

CCA: Coronal Cobb angle

CT: Computed tomography

NSCLC: Non-small-cell lung cancers

PBCIS: Primary bronchogenic carcinomas invading the spine

PET: Positron emission tomography

27 SCA_{EOR}: Sagittal Cobb angle at the edge of the resection

28 SCA_{T1-T12}: T1-T12 sagittal Cobb angle

29 VB: Vertebral body

30

31 **Abstract**

32 **Objective:**

33 It is unknown if spinal instrumentation is required to prevent deformity
34 after partial vertebrectomy in the treatment of primary bronchogenic
35 carcinomas invading the spine (PBCIS). In this study, we focus on the
36 postoperative spine deformity in patients operated for partial
37 vertebrectomies without instrumentation during en bloc PBCIS
38 resection. Our objective was to determine if deformity depends on the
39 type of vertebral resection and if any vertebral resection threshold
40 can be observed to justify additional spinal instrumentation.

41 **Methods:**

42 This is a retrospective study, including all patients with PBCIS operated
43 without spinal instrumentation from 2009 to 2018. Partial
44 vertebrectomies were classified into categories A, B and C depending on
45 vertebral resection. Patients had a long-term radiological follow-up
46 assessing the spine deformity evolution.

47 **Results:**

48 Eighteen patients were included. The median follow-up was 27 months.
49 Four patients underwent a secondary posterior instrumentation
50 surgical procedure due to progressive spinal deformity. A low-risk

group of deformation was characterized as type A resection and type B resection on less than three vertebrae.

Conclusion:

There are no validated criteria to justify a systematic spinal instrumentation when performing a partial vertebrectomy during en bloc resection of PBCIS. Performed alone without spine instrumentation, both type A and type B resections on less than three resected vertebrae were not subject to sagittal and coronal deformity even after a long follow-up, emphasizing that a systematic stabilization is not needed in this low-risk group. These results could help to reduce the perioperative morbidity of these procedures that are usually long and complex.

Text

Introduction:

Primary bronchogenic carcinomas invading the spine (PBCIS) are mainly represented by non-small-cell lung cancers (NSCLC)^{1,2} located along the costovertebral gutter. When invading the superior pulmonary sulcus tumors (Pancoast tumors), characteristic symptoms are complete or partial Pancoast-Tobias syndrome. Invasion of the ribs, the vertebrae and the subclavian vessels causes pain in the shoulder area; invasion of the lower part of the brachial plexus and invasion of the nerve roots causes radicular pain or muscle weakness; and invasion of the stellate ganglion and sympathetic chain is revealed by Horner syndrome^{3,4}.

Spinal invasion is commonly considered to be a negative prognostic factor in primary bronchogenic carcinomas, making them historically considered as incurable⁵. With the advances in the delivery of chemotherapy, radiation and surgical management, carefully selected patients with spine-invading NSCLC can be eligible to complete surgical resection, allowing a major increase of survival⁶⁻⁸. Neoadjuvant treatment with chemotherapy induction and concurrent radiation followed by complete en bloc resection is now a standard treatment option with demonstrated oncological results^{9,10}. This procedure usually requires thoracic and spine surgery teams and the perioperative mortality rate remains high and varies from 9% to 58%¹⁰⁻¹². A spinal instrumented stabilization is always performed when a complete vertebrectomy is required, increasing the mean operative time, the blood losses and the postoperative morbidities. However, the usefulness of a spinal instrumentation to prevent spine deformity has not yet been assessed, especially concerning partial vertebrectomies. In this study, we focused on the postoperative spine deformity in patients operated with en bloc resection of PBCIS without instrumented stabilization. The objective was to determine if a secondary spine deformity depends on which type of vertebral resection was performed and if any vertebral resection threshold can be observed to justify additional spinal instrumentation.

Patients and Methods:

This is a retrospective single-center study, including all patients with PBCIS operated from 2009 to 2018. Data were retrieved from the electronic medical records. All patients underwent preoperative neoadjuvant chemotherapy and radiation. Immediate preoperative spine invasion was assessed with Weinstein, Boriani and Biagini¹³ (WBB) staging (**Figure 1**) and the Spine Instability Neoplastic Score¹⁴ (SINS) (**Table 1**). Both lung, chest wall resection and partial vertebrectomy were performed during a single-stage procedure. Surgical approaches included anterior cervico-thoracotomy (n=1) and posterolateral thoracotomy with extended incision to expose the spine (n=17). No patient underwent spinal instrumentation during procedure.

Surgical technique

The patient is positioned in lateral position to expose the side invaded by the tumor upwards (Shaw-Paulson approach). A posterolateral incision passing below the tip of the scapula is performed. The scapula is then mobilized laterally and superiorly after a careful dissection of the trapezius and rhomboid muscles. The penetration into the chest cavity is performed laterally to identify the tumor without violating its margins. Intrathoracic procedure including lung, bronchus and vascular dissection is performed by the thoracic surgeon. The incision is then extended posteriorly to expose the affected vertebrae. Partial vertebrectomies using osteotomes are then performed in the affected levels. If the posterior vertebral elements are invaded, the tumor is isolated from the unaffected vertebra by performing a unilateral laminectomy. The dura and nerve roots are then gradually exposed.

Invaded nerve roots are clipped to prevent cerebrospinal fluid leakage and cut. The osteotomy is extended to the vertebral body (VB). It is performed medially to the ipsilateral pedicle, allowing a facet and pedicle removal en bloc with the tumor. The invaded VB osteotomy is performed through osteotomy and followed by the section of the anterior longitudinal ligament. A safety margin is respected to avoid any violation of the tumor. After removing the tumor en bloc (**Figure 2**), mediastinal lymphadenectomy is performed.

Spine balance analysis

Immediate postoperative computed tomography (CT) scan were analysed and compared to preoperative CT scan. We used the classification described by Jain¹⁵ (**Figure 3** and **Figure 4**) and created three groups depending on the quantity of resected bone measured on the CT scan: type A were partial vertebrectomies including costotransversectomy and/or less than 25% VB resection, type B were partial vertebrectomies including pedicle resection and/or facetectomy and/or less than 50% VB resection, and type C were partial vertebrectomies including more than 50% VB resection. The amount of resected VB was measured on a single axial section of the immediate postoperative CT scan. We chose systematically the single axial section showing the most extensive resection of the VB. The vertebra with the most important resection was chosen in case of multiple vertebral resection. Two composite groups were also created: a low-risk group of deformity, including group A and group B_{n<3}, and a high-risk group including group B_{n≥3} and group C. Operative time length, blood loss volume and hospital length of stay

were recorded. Each patient had a long-term clinical and radiological follow up with spine CT scans and spine X-rays. The end-point of the follow-up was at the time of the last X-ray retrieved from medical records, or at the time of the second surgery for spine stabilization if needed. The need for a second surgery was decided by the spine surgeon and after a multidisciplinary consultation. Reoperation for stabilization was decided according to importance of the progressive spine deformity, back pain, performance status, operability and patient demand. Coronal Cobb angle (CCA), sagittal Cobb angle at the edge of the resection (SCA_{FOR}), T1-T12 sagittal Cobb angle (SCA_{T1-T12}) were reported immediately after surgery and at the end of the follow-up (**Figure 5**). The difference between immediate postoperative angles and the late postoperative angles was then reported and compared between each vertebral resection group and according to the number of resected vertebrae. We also provide a qualitative analysis concerning the risk factors of a sagittal deformity over 5° and 10°.

Statistical analysis:

We used Student's *t*-tests for spine angles analyses. The distribution of categorical variables was compared with Fisher's exact test. All tests were two-sided and a p-value of ≤ 0.05 was considered to be statistically significant. Statistical analyses were performed using Statview version 5.0 software (SAS Institute, Cary, NC, USA).

Results:

Eighteen patients were included. The median age was 60 years-old (range 46-81 years-old). Demographic and intraoperative data are summarized in

Table 2. WBB staging and SINS are reported in **Table 3.** The tumor histology was adenocarcinoma in 11 patients, squamous cell carcinoma in 5 patients, and undetermined or other NSCLC in 2 patients. The average blood loss was 1614 ml (200-4500 ml) and average operative length was 390 minutes (range 140-650 min). The average hospital length of stay was 13 days (range 5-37 days). No patient suffered from a serious complication within the 30 days following the surgery. A cerebrospinal fluid leak due to a dural tear occurred in one patient. Three patients underwent type A vertebral resection (Group A), fourteen patients underwent type B vertebral resection (Group B) and one patient underwent type C vertebral resection (Group C). Among group B, five patients had less than 3 resected vertebrae (Group $B_{n<3}$) and nine patients had 3 or more resected vertebrae (Group $B_{n\geq 3}$). The overall average number of resected vertebrae was 2,8 (range, 1-5) from level T1 to T9. The median overall follow-up was 27 months (range 2-109). A second surgical procedure for posterior spinal stabilization was needed for 4 patients (median delay was 8,5 months, range 2-18 months). Among these 4 patients, 3 were re-operated because of back pain and progressive deformity (angles for these patients were reported from preoperative X-rays, and reported in the **Table 4**). All of them had good performance status without progression of their disease. The fourth reoperated patient received emergency surgery for decompression and stabilization 5 months after en bloc resection because of local tumor recurrence revealed by a spinal cord compression. Among the fourteen other patients, three patients died respectively 5 months, 6 months and 34

months after surgery because of the progression of their cancer. Among the remaining patients (n=11), the median follow-up was 36 months (range 10-109). The variation of angles between immediate and late postoperative assessment by specimen and for each groups are reported in **Table 4** and **Table 5**. Since only one patient was in the group C, we did not perform statistical analysis with this subgroup alone. There was no statistical difference on the sagittal or coronal balance between group A and group B (**Table 6**). Within the group B, resection of three vertebrae or more trended to be associated with a higher risk of sagittal deformity, even if the statistical significance was not reached with $p=0,061$ (SCA_{EOR}) and $p=0,066$ (SCA_{T1-T12}). Among the composite groups, the high-risk group showed significantly more sagittal deformity at the end of the follow-up ($p=0,01$) (**Table 6**). We then made a categorical analysis of which patients had a progression of the sagittal kyphosis of more than 5° and more than 10° . We confirmed that the high-risk group was significantly associated with a worsening of the local and regional kyphosis ($p=0.01$ and $p=0.004$, respectively) whereas the low-risk group was not (**Table 7**). This trend showing a threshold in term of sagittal balance when more than 3 vertebrae were resected was supported by our clinical experience: within the four patients who needed additional spinal stabilization, three patients were from group $B_{n \geq 3}$ and one of them was from group C, all of them belonging to the high-risk group.

Discussion:

226

227 *Preoperative status, assessment and staging of the disease*

228 The management of BPCIS has evolved through the last decade. Tumors

229 with an invasion of the spine have long been considered as inoperable

230 and fatal⁵. An appropriate staging with a careful assessment of the

231 oncologic status prior to the surgery is essential to choose between

232 therapeutic options. Actually, an incomplete tumoral resection is

233 associated with a poorer oncologic outcome^{6,16}. The Tumor, Node and

234 Metastasis classification makes chest wall involvement at least grade

235 T3 and VB involvement grade T4¹⁷. Preoperative evaluation of the

236 mediastinum with CT, MRI, positron emission tomography (PET) and/or

237 mediastinoscopy are required to determine lymph nodes invasion and

238 metastatic status before any curative surgery attempt. The role of

239 preoperative radiotherapy and chemotherapy is widely supported in the

240 literature^{5,6,10,18-20}. Potential benefits are the decrease in the size of

241 the tumor, the improved resectability and a lower dissemination rate of

242 the tumor during surgery¹⁰. Various classifications about primary and

243 secondary bone tumors are provided in the literature. The aim of these

244 classifications is to help the surgeon in planning the most appropriate

245 tumoral resection in spinal tumors. The WBB staging¹³ were reported to

246 describe with more accuracy the characteristics of our cohort, even if

247 the relevance of this classification is not evaluated for PBCIS. In our

248 study, the local extension often came from the junction between the rib

249 and the VB by contiguity invasion, explaining why the WBB sector was

usually scored between 3-4 and 9-10 and always started at layer A. The SINS was developed by Fisher et al¹⁴ to define neoplastic-induced instability of the spine. The SINS was also quite homogenous due to contiguity invasion of the VB: involvement of spinal posterior elements was always unilateral (score = 1), without VB collapse (score 0 or 1), and without spinal alignment abnormalities or deformity (score = 0).

Surgical techniques

Different surgical techniques have been described for lung cancers invading the spine. Intralesional resection was studied by several authors like Bolton et al²¹ who reviewed two case-series of 17 patients and 39 patients with NSCLC invading the spine, or Bilsky et al²² who also reported 42 intralesional approach with a combined two-staged procedure (posterolateral approach and midline posterior approach). Grunenwald et al⁶ reported a 19-patients study of superior and non-superior sulcus tumors invading the spine treated with en bloc surgical technique. Fadel et al²⁰ and Collaud et al¹⁶ also performed en bloc resection technique in a 54-patients study (although 17 patients were concerned with hemivertebrectomies) and in a 48-patients study respectively, both with excellent overall survival rates. Rates of local and distant recurrence seem similar between these different methods, whether the en bloc resection or the intralesional technique was performed. However, more recent reports favour en bloc resection through less invasive procedures: Stoker et al²³ reported a case-series

of 8 en bloc resection with a sequential video-assisted thoracoscopic surgery combined with posterior spinal resection, showing a lower estimated blood loss quantity and lower length of the hospital stay. Tomita et al²⁴ and Jain et al¹⁵ described a single-stage posterior midline approach for en bloc resection with circumferential spinal stabilization. This approach offers a one-stage definitive resection and stabilization. Overall comparison of previously cited studies tends to show a better rate of complete resection with en bloc resection techniques^{6,10,16,25}. In our study, all patients underwent a single-stage procedure through a posterolateral thoracotomy with an extended incision over the posterior midline to expose the spine. When an anterior cervico-thoracotomy was required due to anatomical consideration, no second-stage was necessary because posterior spinal instrumentation was not performed. All resections were performed with en bloc technique without violating the edge of the tumors.

Survival status and perioperative morbidity and mortality

In most studies involving surgical treatment with vertebral resection, the 5-year survival rate ranges between 10 and 61%^{6,15,21,22}. High rates of postoperative morbidity or mortality^{6,10,16,18,20,25} makes surgical management challenging for multidisciplinary teams. Trying to reduce operative time length and blood loss is a key point to improve postoperative course. Various postoperative complications are reported in the literature: bronchopleural fistula, meningitis, atelectasis, acute respiratory distress syndrome, hypovolemia, deep infection, compression

fracture at the distal end of instrumentation, spinal device dislocation or wound dehiscence²³. Few reports take into consideration operative blood loss and mean operative time. Stoker et al²³ reported a mean estimated blood loss of 813 mL for video-assisted thoracoscopic thoracotomy combined to posterior spinal approach, and an estimated blood loss of 1250 mL concerning opened thoracotomies. In our study, the mean operative time reported was 367 minutes (thoracoscopic thoracotomy) and 518 minutes (opened thoracotomy). Anraku et al¹⁰ reported an analysis over 23 consecutive patients with systematic spinal instrumentation. Nine patients underwent a one-stage operation and 14 underwent a two-stage operation. The average number of vertebrae resected were 3,5 (staged surgery) and 2,5 (1-stage surgery), which seems to be comparable to the average number of vertebrae resected in our study (n=2,8). Mean operative time was 12,3 hours and 19,3 hours respectively with mean blood loss during surgery of 2700 mL and 4000mL respectively. Median duration of hospitalization was 23 days and 2 patients (8,7%) died during immediate postoperative course because of pneumonia and bronchopleural fistula. In our study, we report lower operative blood loss (mean bleeding was 1614 mL), lower operative time (mean operative time was 390 minutes), lower duration of hospitalization (median was 13 days) and no postoperative death.

Spinal instrumentation and spine deformity

There is no consensus about spinal instrumentation after partial vertebrectomy for PBCIS. Bolton et al²¹ performed instrumentation

324 only in case of total vertebrectomy (n=15) excepted for the case of one
325 patient who underwent resection of all posterior elements over two
326 adjacent levels. However, most authors perform at least anterior or
327 posterior instrumentation, or even both anterior and posterior
328 instrumentation in case of pre-existent spinal deformity or multilevel
329 vertebral involvement²⁶. From our experience, the outcomes in terms of
330 spinal deformity depend on the type of the vertebral resection and on
331 the number of adjacent resections. It is commonly admitted that type A
332 resections do not require complementary spinal instrumentation
333 whereas type B resections require posterior instrumentation and type C
334 resections require both anterior and posterior instrumentation^{15,27}.
335 While we found this postulate acceptable for type A and type C
336 resection, we made the hypothesis that type B resection group does not
337 require complementary spinal instrumentation in any cases. To our
338 knowledge, no vertebral resection threshold was previously reported
339 in the literature to justify spinal instrumentation. There is also a
340 paucity of the literature concerning deformity issues and outcome
341 concerning this population. Our results suggest that type A and type B
342 with less than 3 resected vertebrae (low-risk group) are not subject to
343 important sagittal and coronal deformity even after a late follow-up
344 while type B on more than three vertebrae and type C resection are
345 more likely to present a sagittal deformity. Statistical difference
346 between low risk and high risk groups was only reached in term of
347 sagittal deformity. This suggesting that a systematic stabilization
348 might be avoided in the low-risk group, thus limiting the surgical

morbidity associated with these procedures. However, our study clearly suffers from a lack of statistical power. Further investigations with larger controlled case-series are needed to confirm these results.

Conclusion:

Selected patients with PBCIS are eligible to curative surgical attempt with en bloc resection including complete or partial vertebral resection. There are no validated criteria to justify a systematic spinal instrumentation in these procedures. Our results suggest that selected patients with partial vertebrectomies do not need additional spine stabilization. A low-risk profile remains to be defined with a higher level of evidence but our results suggest that this profile depends on the type of vertebral resection combined with the number of resected vertebrae. These results could help to reduce the perioperative morbidity of these procedures that are usually long and complex. Further prospective studies are needed to validate these preliminary results.

Figures

Figure 1 (COLOR)

Modified Weinstein, Boriani and Biagini (WBB) surgical staging system by consensus of the Spine Oncology Study Group. 12 radiating zones are numbered from 1 to 12 in a clockwise order. Six concentric layers are described: A (extraosseous soft tissues), B (intraosseous superficial), C (intraosseous deep), D (extraosseous extradural), E (extraosseous intradural) and F (Vertebral artery involvement).

375

376

Figure 2 (COLOR)

377 Specimen of an en bloc resected tumor involving lung, chest wall and
 378 three vertebrae.

379

380

Figure 3 (COLOR)

381 Different types of partial vertebrectomies: type A partial
 382 vertebrectomy includes costotransversectomy and/or less than 25%
 383 vertebral body resection, type B partial vertebrectomy includes
 384 pedicle resection and/or facetectomy and/or less than 50% vertebral
 385 body resection, and type C partial vertebrectomy includes more than
 386 50% vertebral body resection.

387

388

Figure 4

389 CT scan axial section reconstructions showing Type A (A), Type B (B) and
 390 Type C (C) partial vertebrectomies.

391

392

Figure 5 (COLOR)

393 Thoracic spine represented on sagittal plane (left) and on coronal
 394 plane (right). Yellow marks illustrate T1-T12 sagittal Cobb angle
 395 (SCA_{T1-T12}), red marks illustrate sagittal Cobb angle at the edge of the
 396 resection (SCA_{EOR}) and blue marks illustrate coronal Cobb angle (CCA).

397

Tables

398 **Table 1: The Spine Instability Neoplastic Score (SINS)**

399

400

Table 2: Preoperative spinal invasion assessment: Weinstein, Boriani, Biagini (WBB) classification and Spine Instability Neoplastic Score (SINS).

Table 3: Characteristics of the surgical cohort

Table 4: Difference between immediate and late CCA, SCA_{EOR}, SCA_{T1-T12} by specimen.

Table 5: Difference between immediate and late CCA, SCA_{EOR}, SCA_{T1-T12} by subgroups.

Table 6: Comparison of spine deformity depending on type of vertebral resection

Table 7: Comparison of effectives with variation of the sagittal kyphosis over 5° and over 10°

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A **B** **C**

Element of SINS	Score
Location	
Junctional (occiput -C2, C7-T2, T11-L1, L5-S1)	3
Mobile spine (C3-C6, L2-L4)	2
Semi-rigid (T3-T10)	1
Rigid (S2-S5)	0
Pain relief with recumbency and/or pain with movement	
Yes	3
No (occasional pain but not mechanical)	1
Pain free lesion	0
Bone lesion	
Lytic	2
Mixed (lytic/blastic)	1
Blastic	0
Radiographic spinal alignment	
Subluxation/translation present	4
De novo deformity (kyphosis/scoliosis)	2
Normal alignment	0
Vertebral body collapse	
>50% collapse	3
<50% collapse	2
No collapse with >50% body involved	1
None of above	0
Posterolateral involvement of the spinal elements	
Bilateral	3
Unilateral	1
None of the above	0

Table 1: The Spine Instability Neoplastic Score (SINS).

Variables		n (%)
Gender	Female	4 (22)
	Male	14 (78)
Histology	Adenocarcinoma	11 (61)
	Squamous cell carcinoma	5 (28)
	other	2 (11)
Type of vertebral resection	Type A	3 (17)
	Type B	14 (78)
	Type C	1 (5)
Number of vertebral resection	One	0
	Two	9
	Three	6
	Four	2
	Five	1
Level of vertebral resection	T1	4
	T2	9
	T3	11
	T4	9
	T5	5
	T6	4
	T7	2
	T8	3
	T9	2
Residual margin	R0	16 (89)
	R1	2 (11)
Blood loss	Median (ml)	1400
	Standard deviation (ml)	1157
		5
	>1000ml	7
	1000-2000ml	6
Hospital length of stay	>2000ml	
	Median (days)	11
	Standard deviation (days)	7,7
		7 (39)
	<10 days	9 (50)
	10-20 days	2 (11)
Survival	>20 days	
	Survival	15 (83)
	Death	3 (17)
Second surgery for spinal instrumentation	12-months survival rate (%)	86
	Second surgery	4 (22)
	No second surgery	14 (78)

Table 2: Characteristics of the surgical cohort

Case	Weinstein, Boriani, Biagnini (WBB) classification		Spine Instability Neoplastic Score (SINS)
	WBB Sector	WBB Level	
1	7-8	A-B	7
2	5-6	A-C	4
3	5-7	A-B	7
4	7-10	A-C	11
5	4-6	A-B	7
6	8-10	A-C	8
7	8-11	A-B	9
8	8-10	A-D	9
9	8-10	A-C	9
10	7-9	A-C	7
11	4-7	A-C	9
12	8-10	A-C	7
13	3-7	A-C	9
14	7-10	A-D	9
15	3-5	A-C	9
16	3-4	A-C	7
17	6-9	A-B	7
18	6-11	A-D	10

Table 3: Preoperative spinal invasion assessment: Weinstein, Boriani, Biagini (WBB) classification and Spine Instability Neoplastic Score (SINS).

Case	Vertebral Resection Type	Difference between immediate and late CCA (°)	Difference between immediate and late SCA _{EOR} (°)	Difference between immediate and late SCA _{T1-T12} (°)	Later instrumented stabilization
1	A	0	0	2	no
2	A	0	0	3	no
3	A	3	1	2	no
4	B	8	21	23	yes
5	B	2	1	2	no
6	B	0	6	10	no
7	B	16	23	26	yes
8	B	4	16	16	no
9	B	3	3	6	no
10	B	1	0	2	no
11	B	7	3	4	no
12	B	3	0	3	no
13	B	0	26	30	no
14	B	15	52	58	yes
15	B	6	3	4	no
16	B	3	1	2	no
17	B	0	0	0	no
18	C	16	17	25	yes

Table 4: Difference between immediate and late CCA, SCA_{EOR}, SCA_{T1-T12} by specimen.

Vertebral resection subgroups	Difference between immediate and late CCA (°)	Difference between immediate and late SCA_{EOR} (°)	Difference between immediate and late SCA_{T1-T12} (°)
Group A <i>mean</i> <i>median</i>	1 0	0 0	2 2
Group B <i>mean</i> <i>median</i>	5 3	11 4	13 5
Group B _{n<3} <i>mean</i> <i>median</i>	3 3	1 0	2 3
Group B _{n≥3} <i>mean</i> <i>median</i>	6 4	16 16	19 16

Table 5: Difference between immediate and late CCA, SCA_{EOR}, SCA_{T1-T12} by subgroups.

Variables	n	p-value	95% Confidence interval
<u>Group A vs Group B</u> Coronal deformity: CCA Sagittal deformity: SCA _{EO} R Sagittal deformity: SCA _{T1-T12}	3 vs 14	0.225 0.235 0.286	-10.300 ; 2.629 -29.857 ; 7.953 -31.439 ; 9.962
<u>Group B_{n<3} vs Group B_{n≥3}</u> Coronal deformity: CCA Sagittal deformity: SCA _{EO} R Sagittal deformity: SCA _{T1-T12}	5 vs 9	0.628 0.061 0.066	-7.557 ; 4.749 -32.192 ; 0.903 -34.520 ; 1.320
<u>Low-risk group vs High-risk group</u> Coronal deformity: CCA Sagittal deformity: SCA _{EO} R Sagittal deformity: SCA _{T1-T12}	8 vs 10	0.092 0.010 0.007	-9.566 ; 0.816 -28.726 ; -4.523 -31.982 ; -5.934

Table 6: Comparison of spine deformity depending on type of vertebral resection

Variables	n	SCA_{EO}R (p-values)*	SCA_{T1-T12}(p-values)*
<u>Kyphosis progression over 5° in sagittal plane</u>			
Group Bn<3 versus Group Bn>=3	5 vs 9	0.031	0.031
Low-risk group vs High-risk group	8 vs 10	0.025	0.004
<u>Kyphosis progression over 10° in sagittal plane</u>			
Group Bn<3 versus Group Bn>=3	5 vs 9	0.086	0.031
Low-risk group vs High-risk group	8 vs 10	0.013	0.004

**Fisher exact test*

Table 7: Comparison of effectives with variation of the sagittal kyphosis over 5° and over 10°.