Traumatic spinal fractures the fall and rise

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PART 4

THE CONSEQUENCES OF LATE COLLAPSING SPINAL FRACTURES

CHAPTER 8

THORACOSCOPIC CORRECTION OF POST-TRAUMATIC KYPHOSIS WITH AN EXPANDABLE CAGE: RADIOLOGIC AND PATIENT-REPORTED OUTCOMES

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Abstract

Background

Post traumatic kyphosis (PTK) after insufficient treatment of unstable fractures might be accompanied by pain and decreased back function. PTK can be treated surgically through a minimally invasive thoracoscopic approach with an anterior titanium cage. The results of this treatment have not previously been reported. A retrospective study was performed to determine the long-term functional and radiological outcomes after thoracoscopic PTK correction (PTKC).

Methods

Data was collected of all patients that underwent thoracoscopic PTK correction with an expandable cage between 2007 and 2017. Kyphosis and intervertebral body height (IBH) was assessed on radiographic material. Quality of life (QOL) and functional outcome scores were determined using EQ5D and ODI. Additionally satisfaction and subjective symptom improvement were determined.

Results

Fourteen patients were treated for symptomatic PTK through a combined thoracoscopic anterior and posterior approach. Nine received initial conservative fracture treatment and five underwent initial posterior fracture fixation. All patients presented with pain and without neurologic injury. Mean time between injury and PTKC was 15,4 months. Cobb angle's (CA) improved with 10,6° immediately after PTKC. During the first follow-up 4,8° kyphosis correction was lost, but CA's remained stable at longer follow-up. Bony fusion was achieved in 92% of patients after 16 months. The majority reported 85 months after surgery improvement of symptoms, satisfaction and willing to undergo the procedure again. The mean EQ-5D index score was 0,71 and the mean ODI score was 22,3.

Conclusions

The results of minimal invasive thoracoscopic PTKC using an expandable cage are satisfactory. The majority of patients is satisfied after treatment and no neurological complications occurred. Functional and QOL scores are fairly good. While some post-operative kyphosis correction is lost over time, bony fusion was achieved in the majority of the patients. The thoracoscopic approach minimizes surgical morbidity, does not lead to serious complications and provides a good option for PTK correction.

Introduction

Undesirable late consequences of traumatic thoracolumbar fractures are spinal deformity and pain. This is mostly due to loss of vertebral body height after insufficient conservative treatment of unstable fractures. However, this might also occur after single posterior instrumentation as a result of insufficient load sharing capacity[1], non-union and/or osteonecrosis of the vertebral body with subsequent implant failure[2]. The posttraumatic deformity of the spine usually presents as severe kyphosis which may cause pain and decreased back function[3-5]. Generally, two types of treatment options for posttraumatic kyphosis correction are available, posterior osteotomies and anterior lengthening. Posterior osteotomies include pedicle subtraction osteotomies (PSO) and posterior column shortening (Smith-Peterson osteotomies, SPO). Anterior lengthening might be done using solely anterior fixation[6,7] or with combined anterior and posterior fixation[8,9].

While the correlation of kyphosis with functional outcomes has not been proven, it has been reported that kyphosis over 30° leads to significant back pain[4,5]. Furthermore, patients with a pre-operative sagittal index of over 15°, have been reported by Farcy et al.[10] to potentially benefit from PTKC. In addition to pain, a new or increasing neurologic deficit is also an indication for surgical treatment of posttraumatic kyphosis (PTK). Finally the cosmetic appearance of a severe deformity can be a relative indication for surgical treatment. The applied surgical approach still mainly depends on preference of the treating surgeon[11]. Posterior column shortening is especially effective in treating sagittal disbalance in degenerative multilevel deformities[12] and ankylosing spondylitis. However most patients with a posttraumatic deformity do not have sagittal disbalance due to compensatory changes in other uninjured spine segments[4]. In these patients anterior lengthening on the level of the collapsed vertebral body can be considered a logical alternative to PSO in treating posttraumatic kyphosis.

Augmentation of the anterior column with titanium cages instead of autografts prevents the disadvantages of autografts[13]. Additionally, the use of a minimally invasive thoracoscopic approach[14,15] prevents the morbidity of an open technique[16,17] and improves visual exposure of the anterior column at the same time. The value of this approach has been proven in the treatment of unstable fresh spinal fractures[18]. The outcomes of anterior correction with an expandable cage through a minimal invasive thoracoscopic approach for the correction of PTK however have not yet been reported. We therefore report the radiologic, clinical and functional results of the first series of patients that have been treated through the abovementioned method for focal posttraumatic kyphosis.

Materials and methods

All patients that underwent thoracoscopic correction of posttraumatic kyphosis between 2007-2017 in our level 1 trauma center were analyzed. All patients had failed initial treatment of a traumatic thoracolumbar fracture. Initial treatment was conservative or surgical with posterior fixation, performed in a referring regional center or our academic trauma center. Indications for posttraumatic kyphosis correction were severe or increasing kyphosis with impairing pain.

Data collection

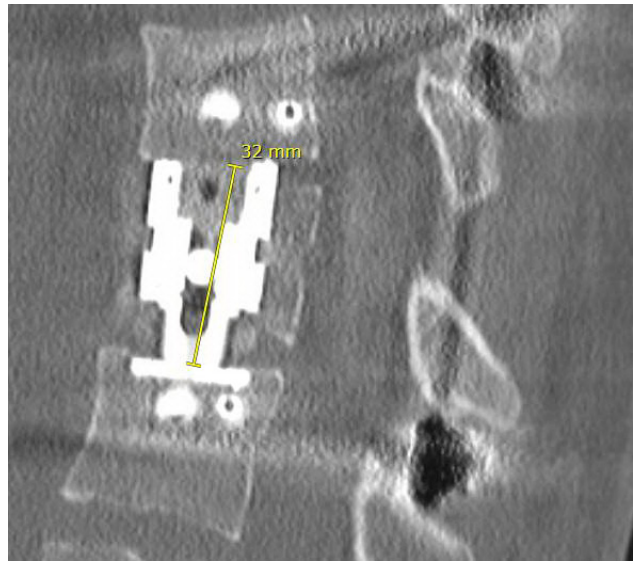
Baseline data and patient characteristics (age, sex, mechanism of injury, level and type of fractured vertebra, injury severity (ISS), neurologic injury, initial treatment, kyphosis correction date and method, implants, segments fused, complications) were retrospectively collected from the hospital information system. Current quality of life (QOL) and back pain disability were assessed using two validated questionnaires, respectively the Euroqol 5 dimensions (EQ-5D) and the Oswestry Disability Index (ODI). The EQ5D is scored on five dimensions from which an index score can be calculated based on the general population of a specific country with 1 corresponding with full health and 0 corresponding with death. Additionally a VAS score is filled in, corresponding with current health at the reported day (100 = full health and 0 = worst health). The ODI consists of ten domains from which an over-all low back pain disability score can be calculated (100%= complete disability and 0%= no disability). A demographic questionnaire consisting of four questions concerning treatment satisfaction and NRS-rated back pain over the last week was sent along with the validated questionnaires. The study was approved by the institutional medical ethical review board (METc VUmc) under case number 2017.183.

Radiographic parameters

All available radiographic material was reassessed by two separate authors for fracture characteristics (AO classification), kyphosis (Cobb angle), intervertebral body height (IBH) and bony fusion. Kyphosis, IBH and bony fusion were assessed over time at each follow-up moment available. Kyphosis was assessed using Cobb angle (CA)[19] on sagittal CT when available and otherwise using MRI or plain lateral radiographs. Additionally the sagittal index was determined as segmental kyphosis (CA) adjusted for the baseline sagittal contour at that level[4,10].

Fusion was scored by two experienced spine surgeons on CT-scan. IBH was identified as the distance between the center of the inferior and superior endplates of the vertebra above and below the index vertebra, measured on mid-sagittal CT (Fig 1). If disagreement existed concerning measurements or fracture classifications, another experienced spine surgeon was consulted.

Fig 1. Example of Intervertebral Body Height (IBH) measurement



Surgical technique

Two surgeons performed all surgeries. The posttraumatic kyphosis correction procedure consisted of three stages in one session; thoracoscopic minimal invasive anterior release, posterior instrumentation and kyphosis correction and finally thoracoscopic anterior fixation with a cage and anterolateral plating. The thoracoscopic procedure was performed as described by Beisse et al[15,18] and the cell-saver is used during the procedure. In the first stage, the patient is positioned in the left or right lateral decubitus position, depending on the level of the fractured vertebra and it's relation to the anatomic position of the greater vessels. Single lung ventilation is then applied. The targeted vertebra is then identified under further fluoroscopic guidance and the portals are inserted into the thorax. The first portal is inserted under direct visualization using a slightly larger skin incision (approximately 4 cm). The other trocars are inserted under direct visualization through the scope (Fig 2a). The lung is retracted using the fan retractor and to access the caudal part of the thoracolumbar junction (T12-L2) the crus of the diaphragm is slightly detached and pushed caudally. To access the lumbar vertebrae, the psoas muscle additionally has to be partly dissected. The anterior release is performed by dissecting the anterior ligaments and ossifications, a partial or complete corpectomy with discectomy is performed using a rongeur with maintenance of the posterior vertebral wall. Additionally an anterior spinal cord decompression can be performed in this stage. Two lateral screws of the anterolateral plating (MACS-TL, Braun, Melsungen, Germany) are already placed in each vertebra above and below the kyphotic vertebra. The corpectomy

Fig 2. Per-operative situation with (a) trocars in situ and post-operative situation (b) with closed portal incisions.

space is then temporarily filled up with a gauze and the wound is provisionally closed before continuing to the second stage. The patient is then positioned in prone position. Pedicle screws and rods are inserted through an open approach and segmental kyphosis reduction is applied under fluoroscopic guidance by direct pressure and distractive forces on the pedicle screws. If the kyphosis is corrected sufficiently and fixated with the pedicle screws and rods, the wound is closed and the patient is again positioned in lateral decubitus position. The portals are re-inserted, the gauze is removed from the corpectomy space and the expandable titanium cage (Obelisc, Ulrich medical, Ulm, Germany) is placed and expanded until it has good grip on the endplates. The lateral plate (MACS-TL) is then placed over and fixated to the previously inserted lateral screws. Finally the cage and anterolateral plate are surrounded with corpectomy bone augmented with demineralized bone matrix (DBX, Depuy Synthes or Cerasorb, Curasan) to stimulate bony fusion. A collagen sponge coated with fibrinogen and thrombin is applied over the construct (Tachosil). The diaphragm and wounds are then closed and a thoracostomy tube is left in place for 48 hours (Fig 2b). The patient is allowed to mobilize after 24 hours with physiotherapy.

Statistics

Continuous variables following a normal distribution are presented as means with corresponding standard deviation (SD), not-normally distributed variables are presented as median with interquartile range (IQR). Dichotomous or categorical variables are presented as proportions. Comparison of continuous variables with normal distribution between two groups was done using a t-test or linear regression. Correlations between continuous outcomes were tested visually for outliers with scatterplots, then assessed for significance with linear regression and if needed corrected for outliers. Statistical significance was regarded as $p<0,05$. Statistical analyses were done using IBM SPSS 22.0.

Results

Between 2007 and 2017 fourteen patients were treated for symptomatic posttraumatic kyphosis using a thoracoscopically placed expandable cage. The mean age at injury was 42 years (range 13 – 69) and ten of these patients were referred from regional hospitals due to unsatisfying results of primary treatment. All fractures were originally located between T6 and L2 and most were A4 type fractures. None of the patients had neurological impairment before or after surgery. Additional patient characteristics are reported in Table 1. Mean time between injury and PTKC was 15,4 ± 10,6 months (range 2 – 36), Table 2. Fig 3 shows an example of a pre- and postoperative CT scan.

Primary fracture treatment

Primary fracture treatment consisted of posterior fixation with pedicle screws and rods in five patients. Nine patients were primarily treated with conservative treatment. Five of them received an orthosis. Two patients did not receive any initial treatment due to patient delay and in two referred patients it remained unclear if any specific conservative treatment was received. Four of the five patients treated with dorsal fixation as primary treatment underwent this within one week after injury, one patient was dorsally fixated after ten weeks when conservative treatment appeared not sufficient.

Indications and surgical technique

All patients with post-traumatic kyphosis presented with pain and severely progressed kyphosis over time from injury. Ten patients were treated through a single session three-staged anterior-posterior-anterior approach. Initially, nine of them were treated conservative and one with posterior fixation, fusion and secondary implant removal. This patient required a laminectomy due to initial posterior fusion and was therefore treated with the three-staged procedure. Posterior fixation is usually not performed with fusion in our center and this patient was initially treated in another country. Four patients underwent only anterior thoracoscopic treatment after failure of initial posterior instrumentation (without fusion). Two of these patients had already undergone removal of posterior instrumentation with secondary collapse. Blood loss for patients with only anterior instrumentation consisted of median 1450 (IQR 1225 – 1975) mL, for the combined three-staged anterior-posterior-anterior approach this was in total a median of 1525 (IQR 1075 – 2500) mL. The cell-saver reduced blood loss to respectively 1032 (IQR 174 – 1320) mL and 1375 (IQR 813 – 2457) mL. As experience with the technique increased over time, blood loss decreased, although not significantly (R^2=0,12; p=0,33). Operative time was mean 286 ± 49 minutes for the anterior approach and 470 ± 105 minutes for the three-staged anterior-posterior-anterior approach. Operative time decreased over time, however not significantly (R^2=0,27; p=0,15), Fig 4.

Table 1. Patient characteristics

N	**14**
Male:Female	7:7
Age (years, mean ± SD)	43 ± 18
ISS (score, mean ± SD)	12 ± 9
- < 16 (n=10)	7,8 ± 2,9
- ≥ 16 (n=3)	26,7 ± 2,5
Multiple fractures	3 (21%)
Fracture level:	
- T6, T8, T9, T10, L2	1 (7%)
- T7	2 (14%)
- T12	4 (29%)
- L1	3 (21%)
Fracture type (AO)a	
- A3	2 (14%)
- A4	12 (86%)
- B/C type	1 (7%)
Cobb angle before PTK	
- 10˚	1 (7%)
- 20-30 ˚	8 (57%
- > 30 ˚	5 (36%)
Anterior segments fixation	
- 1	1 (7%)
- 2	12 (86%)
- 3	1 (7%)
Posterior segments fixation	
- 2	7 (50%)
- 3	2 (14%)
- 4	2 (14%)
- 5	1 (7%)
Cage type	
- Synex 2	2 (14%)
- Obelisc	12 (86%)
Additional bone substitute (to corpectomy)	
- DBX	9 (64%)
- Cerasorb	2 (14%)
- Autologous crista bone	2 (14%)
- Only corpectomy bone	1 (7%)
Cause of injury	
- Fall/jump from height	5 (36%)
- Fall from stairs	3 (21%)
- Traffic accident	4 (29%)
- Fall	1 (7%)
- Fall from horse	1 (7%)

[a]Total amount of fractures overlaps total amount of patients because the B type fracture was associated with an A4 type fracture

Fig. 3. Sagittal (A–C) and coronal computed tomography scan (D–F) and sagittal plain X-ray (G–I) of a patient treated with anterior-posterior fixation for PTK: preoperative (A, D, G); postoperative (B, E, H); and two years postoperative (C, F, I).

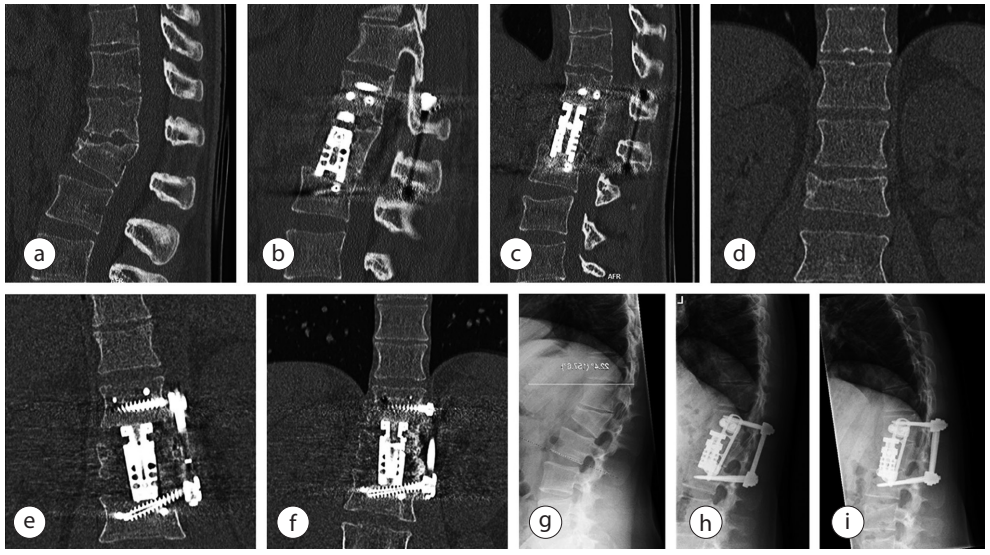


Table 2. Time from injury to PTKC

Primary treatment	n	Weeks injury to PTKC (mean, SD)
Pedicle screws and rods	5	82 ± 55 (range 15 - 156)
Orthosis	5	57 ± 19 (range 24 – 68)
Non-operative, exact unclear	4	55 ± 58 (range 9 – 131)

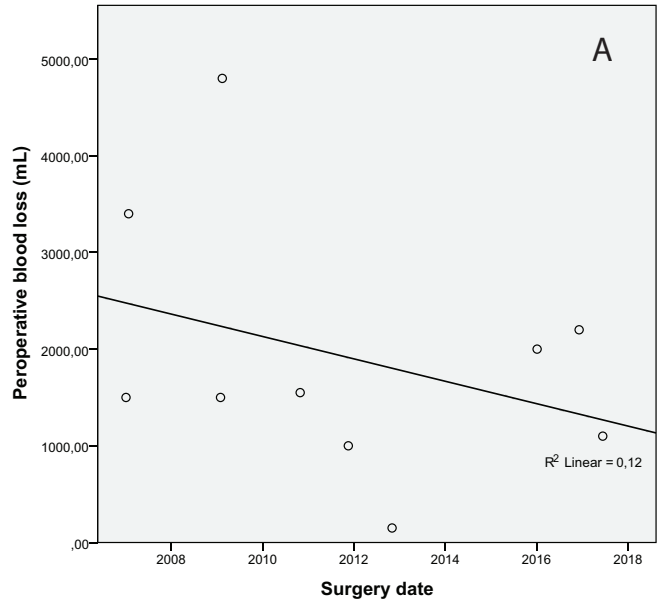
Complications

Two patients developed post-operative complications. One patient developed pulmonary embolisms, a superficial wound infection and pleural empyema. These were successfully treated with respectively anticoagulation, antibiotics and chest tube drainage. Another patient developed pleural fluid without infection which was successfully drained.

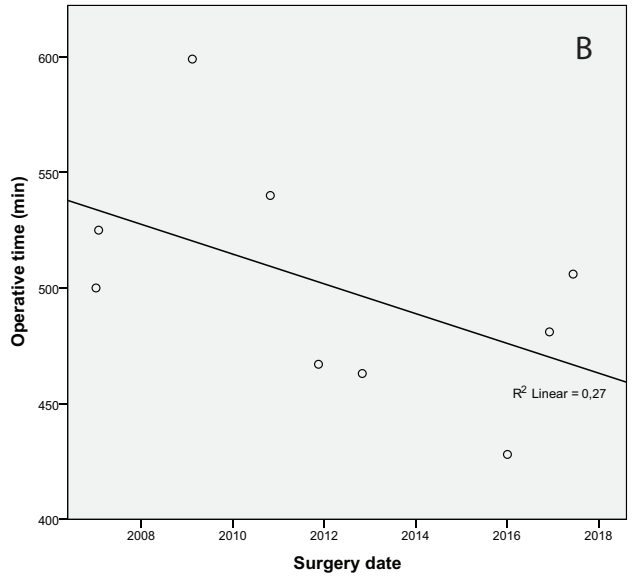
Radiological outcomes

All patients had available pre- and postoperative CT-scans. The mean pre-operative sagittal index was 24,7 ± 6,6 and the mean Cobb angle (CA) was 26,1 ± 9,0. Kyphosis (CA) from pre-operative to immediate post-operative (n=14) improved significantly from 26,1˚ ± 9,0 to 15,6˚ ± 7,4 (mean difference: 10,6˚ ± 8,4; p<0,01). Over time, there was a minor but significant loss of initial kyphosis correction (MD 4,8˚ ± 4,0; p<0,01). For seven patients long-term radiographic follow-up was available, the other patients did not yet reach this follow-up period, did their

Fig 4. Surgical blood loss (a) and operative time (b) evolution for the three-staged procedure



A: n=10; (R^2=0,12; p=0,33)



B: corrected for one outlier; n=9; (R^2=0,27; p=0,15)

follow-up in another hospital or were already discharged from follow-up. Patients with repetitive radiologic follow-up imaging available (n=7) showed stable Cobb angles over time from 11 to 78 months (Fig 5, 6 & table 3). The IBH (mm) increased significantly from pre- to postoperative (MD 4,4 ± 2,8; p<0,01). At follow-up the IBH decreased but remained stable and significantly larger compared to the pre-operative value. Fig 5, 6 & table 4.

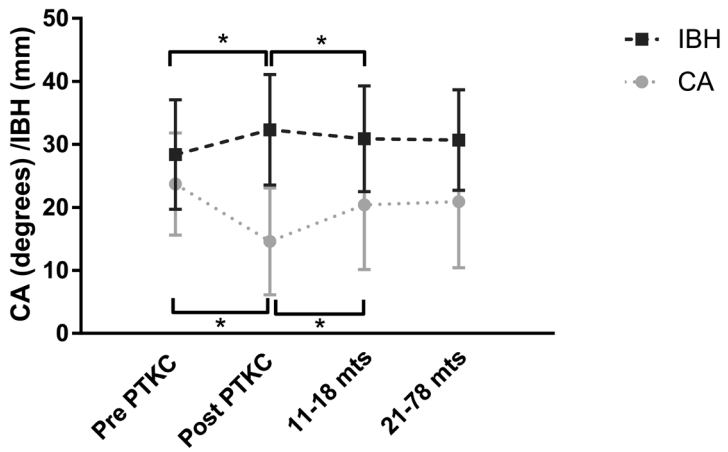
Fusion could be assessed on CT for twelve patients. Eleven of these (92%) achieved bony fusion in mean 17,7 ± 7,5 months. One had not achieved complete bony fusion after 36 months. The remaining two patients were followed-up elsewhere

Table 3. Cobb angle at specific time points

Moment 1	Moment 2	CA (MD; SD)	P†	n
Injury	Pre PTKC	7,1 ± 4,1	*0,002**	8
Pre PTKC	Post PTKC	-10,6 ± 8,4	*0,001**	14
Post PTKC	11-18 mts	4,8 ± 3,8	*0,004**	11
11-18 mts	21-78 mts	0,5 ± 1,1	0,3	7
Post PTKC	21-78 mts	6,4 ± 3,5	*0,005**	9

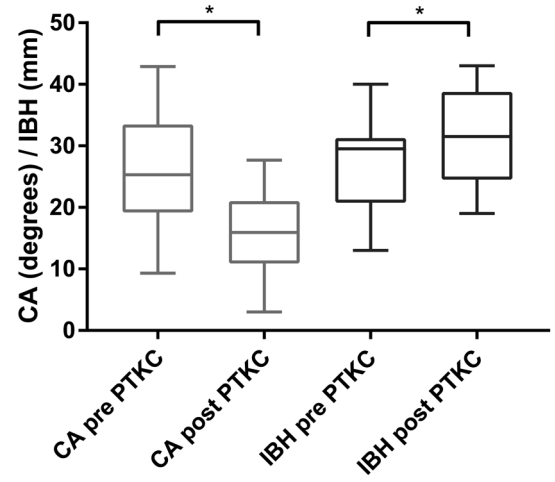
*†paired samples t-test; *statistical significant difference p<0,05*
CA: Cobb angle; MD: mean difference; SD: standard deviation; MTS: months

Fig 5. CA and IBH evolution over time



Points display means with SD (bars).
*CA: Cobb angle; IBH: Intervertebral body height; PTKC: Posttraumatic kyphosis correction; mts: months. *Statistical significant difference (paired t-test; p<0,05)*

Fig 6. CA and IBH before and after surgery



*CA: Cobb angle; IBH: Intervertebral body height; PTKC: Posttraumatic kyphosis correction; *Statistical significant difference (paired t-test; p<0,05) as reported in tables 3 & 4*

Table 4. Intervertebral body height at specific time points

Moment 1	Moment 2	IBH (MD;SD)	P†	n
Pre PTKC	Post PTKC	4,4 ± 2,8	<0,001*	14
Post PTKC	11-18 mts	-1,5 ± 1,1	0,002*	11
11-18 mts	21-78mts	-0,1 ± 1,1	0,7	7
Post PTKC	21-78mts	-2,4 ± 2,7	0,04	8

*†paired samples t-test; * statistical significant difference p<0,05*
IBH: intervertebral body height (mm), MD: mean difference; SD: standard deviation; MTS: months

Functional outcomes & QOL

Of the fourteen patients treated for posttraumatic kyphosis, valid functional outcomes and quality of life scores were reported by nine. Two patients were excluded from additional questionnaires due to respectively psychiatric history and age below sixteen at the time of surgery which was unlikely to produce representative answers. One patients' follow-up period was too short (<6 months) after surgery to provide reliable results. Of the remaining eleven patients, a response rate of 82% was obtained. These nine patients filled in the questionnaires at mean 84,56 ± 46,11 months after surgery (range 7 – 125 months). The mean ODI score was 22,3% ± 18,5% (range 0 – 46) corresponding with moderate back pain related disability. The

mean EQ5D index score was 0,71 ± 0,23 (0,31 – 1,0) and the mean EQ5D VAS score was 69,0 ± 17,1 (range 40 – 90). Domain specific EQ5D scores are shown in Fig 7.

Most patients were satisfied and had improvement of their symptoms. Most patients would undergo the procedure again if they would hypothetically be in the same situation again and there were no reports of severely increased symptoms (Fig. 8).

The mean back pain NRS of the last week before questionnaire was 4,11 ± 2,32 (range 1-8). Analgesics used for back pain were reported by 33,3% (n=3) and 66,7% reported not to use any back pain related medication. One patient reported to use acetaminophen, one patient reported to use opiates and one patient reported to use both.

Fig 7. EQ5D domain specific outcomes

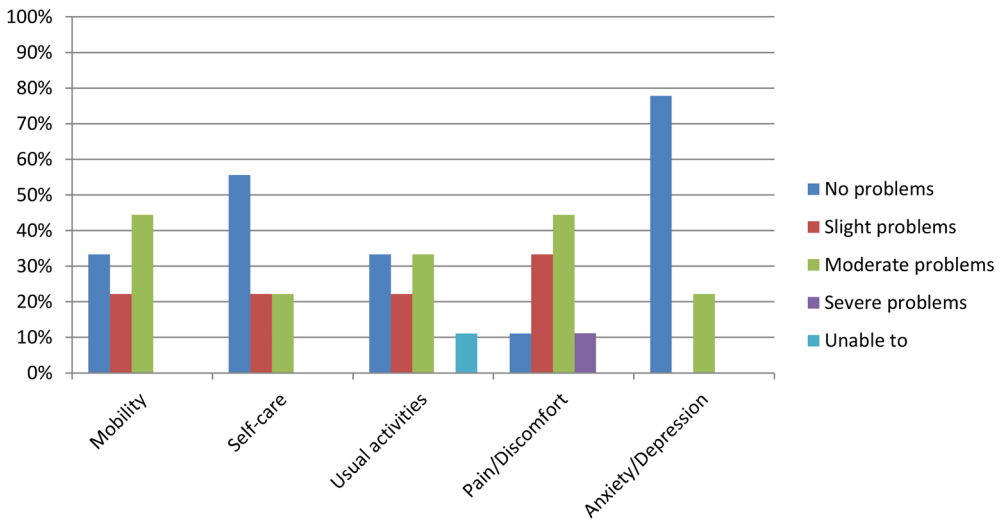
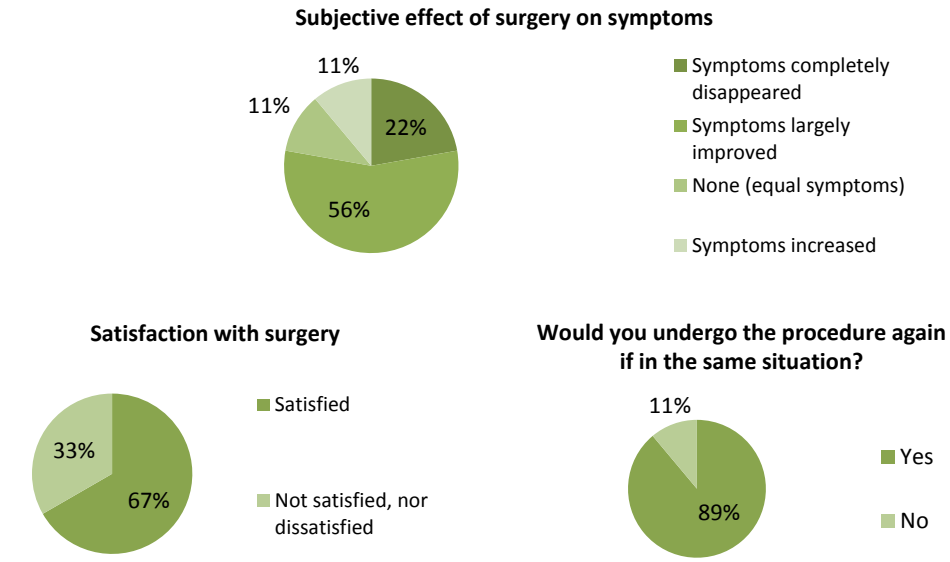


Fig 8. Subjective patient outcomes



Discussion

Posttraumatic kyphosis often occurs in the thoracolumbar and thoracic region. Due to unfamiliarity with the anterior approach, many surgeons tend to use PSO's with the need for long posterior instrumentation. The anterior approach however, provides two-column stabilization with a short immobile segment, sparing remaining motion segments. Additionally, the approach enables removal of any damaged intervertebral disc which might have caused non-union due to collapse into the fracture. In an attempt to combine anterior fixation with minimal surgical morbidity, a mini-open approach has been used[9,20]. An alternative approach is from posterolateral, but this affords limited exposure[21]. The thoracoscopic approach provides excellent exposure, two-column stability and minimizes surgical morbidity. This is the first study to describe the results and patient reported outcomes after PTKC using a thoracoscopic approach.

Post-traumatic kyphosis was corrected significantly during surgery, although over time some correction loss did occur. Most correction loss occurred in the first year, as has been reported before after a thoracoscopic anterior stabilization [16,22] and is partly due to some cage subsidence as the construct settles down. The majority of patients reported improved symptoms, would undergo the surgery again and were satisfied with surgery. Additional functional scores were comparable to those after PSO and no neurologic complications or re-operations were reported.

Radiologic parameters

The average kyphosis correction was 10,6˚, with a correction loss at final follow up of 6,6˚. This is comparable to the only other study that reported anterior-posterior treatment of patients with a pre-operative Cobb Angle < 30˚[23], however in this study bone grafts and an open approach were used. Other studies generally report results of patients with a pre-operative CA > 30˚[6-8]. In these cases, the anterior-posterior approach corrects 30˚-40˚ kyphosis and PSO corrects even more (35˚-47˚) with nearly any correction loss[24-27].

Patients with a pre-operative sagittal index of > 15˚, have been reported by Farcy et al.[10] to potentially benefit from PTKC. All patients presented with pain and had a sagittal index > 15˚ which was not always accompanied by extreme Cobb angles. This strengthens the idea that the sagittal index (>15˚) is a better indication for PTK surgery than Cobb angle alone as the sagittal index corrects for the physiologic difference in CA of different spine regions.

Clinical outcome

Although pre-operative kyphosis generally did not exceed 30˚, the mean sagittal index was largely over 15˚ and all patients presented with symptoms of severe pain. Symptoms improved after surgery in most patients even while some correction loss did occur over time. The majority (>75%) of patients benefitted from surgery by largely or completely improved symptoms after surgery. The average back pain related NRS score for the last week was 4,11 and only three patients still used back pain related analgesics. Successful pain decrease has also been reported after anterior PTKC in patients with severe kyphosis (>30˚) treated with bone grafts, cages and plating[6,7,21]. Furthermore 67% of patients reported to be satisfied with the procedure and there were no patients that were dissatisfied. In addition, 89% reported to be willing to undergo the procedure again if in the same situation, which is higher compared to other studies that used a conventional anterior approach[7,28]. This further indicates the effectiveness of the procedure on patient reported outcomes. For treatment of PTK with PSO, also large pain decreases are reported[24-26], although without further reporting of subjective results.

ODI and EQ-5D

Functional scores after the thoracoscopic anterior treatment of PTK are acceptable and comparable to those treated with a posterior approach. The average reported ODI score in this study (22,3) corresponds with moderate back pain disability which is comparable to most studies that report the results of PTK treated with a modified PSO[25,27,29] . Although one study reported a better ODI after PSO[24], also worse scores are reported after PSO for deformities[30]. Previous comparison of a posterior and anterior approach showed an

increased improvement in ODI scores after PSO, although the anterior procedure was not thoracoscopic and applied only a plate instead of a cage[28].

The mean EQ5D index score reported in this study was 0,71. The QOL after PTK treated with an anterior approach has not yet been reported. Our patients however, scored considerably better compared to patients treated with PSO for adult deformities including posttraumatic kyphosis (0,56)[30].

Surgical parameters and complications

The anterior-posterior approach took considerably longer compared to the anterior only approach, 470 versus 286 minutes respectively, which is largely due to repositioning of the patient. Reported surgical duration for PSO ranges from 149 to 275 minutes[24-30]. The thoracoscopic anterior only approach is slightly longer however we only reported data from four patients. The procedure is performed by experienced trauma surgeons that have expertise in spinal trauma. Apart from thoracoscopic trauma-related spine surgery and acute (intra)thoracic injuries, they do not perform other thoracoscopic procedures on a routine basis. They are however also trained as general surgeons and have abundant experience with laparoscopic surgery. Even though the surgeons had experience with the anterior approach, over time a decrease in operative time was shown for the three-staged procedure. The presence of a learning curve might be explained by the technically demanding technique and the relative infrequent application of PTKC.

The blood loss in the anterior only approach (1450 mL) was mainly a result of continuous oozing from the vertebral body during corpectomy. For the conventional anterior approach this ranges from 470mL to 1250mL[6,8] and for the posterior approach from 643mL to 2300mL[24-30]. The difference in blood loss might be due to individual patient characteristics of the described patients and emphasizes the importance of using a cell saver during the procedure. This substantially reduced the net blood loss to amounts that are within the range reported in the literature. Furthermore, just as for operative time, a decrease in blood loss over time was shown, possibly due to a learning curve. Additionally it might be emphasized that the technique does not primarily aim to reduce blood loss, but merely prevents thoracotomy-related complications such as pain and might lead to good technical results due to improved vision.

Two patients developed complications, one minor and one major. Pleural fluid is a known complication of the thoracoscopic approach and can often be treated without residual symptoms. The thoracoscopic approach is applied to minimize surgical damage and associated complications such as post-thoracotomy syndrome[16,21]. Compared to previous studies with the anterior open approach for PTKC[6,21,23], the amount of complications in our group is low. Furthermore, no neurologic complications occurred, which are reported after PSO's [24,26,27].

Strengths and Limitations

The retrospective design and small patient sample are obvious limitations of this study. Although no validated pre-operative results were available, current validated functional and QOL scores were obtained. No such results have yet been reported in the literature for this procedure. The long-term radiologic follow-up periods were heterogeneous due to some patients (mostly referrals) being followed-up in other hospitals. Additionally the follow-up periods of patient reported outcome measures were heterogeneous because of the large spread in surgery dates and cross-sectional nature of the questionnaires. Due to the small patient sample, maximal efforts were done to collect responses to the questionnaires which resulted in a high response rate of 82%.

Conclusion

The results of the thoracoscopic minimally invasive treatment of established posttraumatic kyphosis are satisfactory. Functional scores are good, comparable to other treatments for PTK and with no neurologic complications. While some post-operative kyphosis correction is lost over time, bony fusion was achieved in the majority of the patients. The majority of patients that completed the questionnaires reported improvement of symptoms, were satisfied and willing to undergo the procedure again. Although larger studies are warranted, the thoracoscopic approach seems safe, technically sound and a good option in treating posttraumatic kyphosis.

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